BOSTON UNIVERSITY

College of Business Administration

THESIS

The Soybean Industry in the United States

by

Mary Ethel Mallery
(B.S. Oregon State College 1929)

submitted in partial fulfillment of
the requirements for the degree of

MASTER OF BUSINESS ADMINISTRATION

1942

TABLE OF CONTENTS

TABLES

TABLES CON'T

INTRODUCTION

The study of the soybean industry is a very interesting and challenging one. It is interesting first, because it is a study of one of the oldest plants known to man. Mr. H. W. Galley, in an article, <u>Soybean Oil--Who Uses It</u>, tells of a very ancient Chinese legend regarding the soybean. (1) According to the legend, a caravan laden with gold, silver, and valuable furs was beset with bandits in eastern China. They took their refuge in a rocky slope. Faced with starvation, a servant discovered a vine-like plant bearing a legume. The beans were pounded into flour and the caravan was supplied with food until help arrived. The legend goes on to say that this plant has been identified as the soybean, and after that time, it became the staff of life in China. It is difficult to realize the importance of the crop to Chinese civilization. It was an accepted rule with each Chinese family to count the number of persons in the family and plant five acres of soybeans for each member.

Secondly, the soybean industry is an interesting study because, in spite of its slow start, it has had a very rapid growth in this country. No other one crop in American history has shown such great increase in acreage

(1) Galley, H. W., <u>Soybean Oil--Who Uses It</u>, The Soybean Digest, Vol. 1, December, 1940, P. 3.

as have soybeans since 1919. It was in the period of agricultural depression between World War I and World War II that the soybean crop grew from a position of obscurity to one of the major cash crops of farmers in the Corn Belt.

The study of the soybean is interesting because of its many uses. No other one crop can be used for so many things. Again, the study of the soybean industry is interesting because of the important part it is playing and will play in the present crisis. It is one of the major crops in defense work and in the "food for victory" program.

It is a challenging study because, in spite of its rapid growth, the industry is still in its infancy. Many uses have been discovered, but at the same time, the potential uses undoubtedly exceed the present uses. It is a challenging study because the industry has very definite problems facing it today. This is said in spite of the fact the industry is having a present period of prosperity. Increased production may solve some problems for the farmers, but at the same time, it creates others.

The study of the soybean industry is challenging because very little has been written on the industry as a whole. Many articles have been written on various

phases of the industry. It is the purpose of this paper to deal with all branches of the industry and to give a general picture of the soybean industry in its entirety.

HISTORY

> "Hou Tsi, one of the Gods of Agriculture, according to Chinese legend, wishing to give humans a superior food, planted a soybean seed. The seed prospered, and from its increase grew great crops, which, for more than one hundred generations have supplied a valuable source of tissue building and repairing food to people who have never known the taste of cow's milk and seldom tasted meat." (1)

This "Little Honorable Plant," so called by the Chinese, is a native of southeastern Asia. In the Asiatic countries it ranks with rice as a food and stands alone in the number of uses to which it may be put. It was used extensively for food long before written records were kept--in fact, it has been a staple food for the Japanese and Chinese over five thousand years. Emperor Shen-Nung of Manchuria, (sometimes called the Father of Agriculture), in writing for a Chinese book on Materia Medica, Ben Tsao Gang Mu, in 2838 B. C., listed no less than two hundred medicinal properties to be found in the soybean. This is the first written record of the plant. Frequent references are made in later records to methods of culture, varieties for different purposes, and numerous uses, indicating the soybean to be of very ancient culture, and perhaps one of

(1) Consumers' Guide, Salute to the World Bean, Vol. III, No. 8, April 20, 1936, P. 3.

the oldest crops grown. The importance of the soybean has been described by one authority in the following terms,

> "It was considered the most important cultivated legume and one of the five sacred grains essential to the existence of Chinese cultivation. Soybean seed was sown yearly with great ceremony by the emperors of China, and poets through the ages have extolled the virtues of the plant in its services to humanity." (1)

Although the soybean is of very ancient origin, it was extremely slow in reaching other countries. It was not made known to Europeans until 1691 when Engelbert Kaempfer, a German botanist, spent two years in Japan and took some seed back to his country. Chinese missionaries sent seed to France as early as 1740, where they were planted in the botanical gardens. The first record of seed being planted in England was in 1790 in the Royal Botanic Gardens in Kew, but at that time no effort was made to cultivate it as a crop. No noticeable gain was made in its cultivation in Europe until 1875, when Friedrich Haberland published results of his investigations in Vienna. Since then, the soybean has been grown experimentally in most European countries, but climatic conditions there are not particularly well suited for

(1) Morse, W. J., Cartter, J. L., Soybeans, Culture and Varieties, United States Department of Agriculture, Bulletin 1520, November, 1939, P. 2.

its cultivation, except in certain parts of Rumania, Czechoslovakia, and Russia.

DEVELOPMENT OF THE SOYBEAN INDUSTRY IN THE UNITED STATES

It is believed that the first soybeans were brought to the United States from China in 1804 by Dr. James Mease, an amateur horticulturist. The first written record in this country was made in that same year when James Mease wrote that, " 'The soybean is adapted to Pennsylvania and should be developed.' " (1) The next time soybeans were mentioned in American literature was in 1829, when Thomas Nuttall wrote in *The New England Farmer*, October, 1829, " 'Its principal recommendation at present is only as a luxury affording the well-known sauce, soy, which, at this time is only prepared in China and Japan.' " (2) Nuttall had grown a variety with red flowers and chocolate brown seeds in the botanic garden at Cambridge, Massachusetts. Two years later, in the same journal, November 23, 1831, is a record of the successful planting of the bean in Milton, Massachusetts, the seed having been obtained from Nuttall. No further mention of the soybean was made until 1853, when a brief account appeared under the name *Japan pea*,

(1) Morse, W. J., Cartter, J. L., *Soybeans, Culture and Varieties*, United States Department of Agriculture, Bulletin 1520, November, 1939, P. 3.
(2) Piper, C. V., Morse, W. J., *The Soy Bean, History, Varieties, and Field Studies*, United States Department of Agriculture, Bulletin 197, December, 1910, P. 26.

by A. B. Ernst, Cincinnati, Ohio, as follows:

> " 'The Japan pea in which so much interest has been manifested in this country for a year or two past, from its hardihood to resist drought and frost, together with its enormous yield, appears to be highly worthy of the attention of agriculturists.' " (1)

In the next year, 1854, the Perry expedition brought back two varieties of soybeans from Japan, one white seeded, the other red seeded. These were distributed by the Commissioner of Patents in 1854, and frequent reference is made after that in agricultural publications to the Japan pea. It is believed that these two varieties were the Ito San and the Mammoth. The Mammoth, so important in the early history of this country, is not mentioned in recent publications.

In 1878 Professor G. H. Cook of New Brunswick, New Jersey obtained seeds from the Bavarian Agricultural States, and Mr. James Neilson obtained seeds of several varieties at Vienna. They both planted these and secured crops of different varieties in 1879. There are records of a yellow-seeded bean being grown at the North Carolina Agricultural Experiment Station in 1885. Two varieties were grown at the Massachusetts Agricultural

(1) Piper, C. V., Morse, W. J., The Soy Bean, History, Varieties, and Field Studies, United States Department of Agriculture, Bulletin 197, December, 1910, P. 26.

Experiment Station in 1888. The following year Professor W. P. Brooks of Amherst, Massachusetts, brought a number of varieties from Japan. "Since 1890 most of the agricultural experiment stations have experimented with soybeans and many bulletins have been published dealing wholly or partly with the crop." (1) Beginning in 1898 the United States Government introduced many new varieties. Previous to that time there were no more than eight varieties of soybeans grown in the United States.

Thus we see that soybeans were introduced to this country in the early part of the nineteenth century, and at the end of that century very little had been done in the development of the industry. The soybean was first mentioned in the United States Department of Agriculture Yearbook in 1902 when it was listed as a "leguminous cover crop for peach orchards." It was not mentioned in this publication again until 1907, when, in the report of the Secretary, on Soy Beans for Rotation on Rice Lands, it was stated:

> "The rice growers of the south, especially in Louisiana and Texas have long felt the need of a legume that might be grown in rotation on their rice lands. The Department has been successful in introducing

(1) Piper, C. V., Morse, W. J., The Soy Bean, History, Varieties, and Field Studies, United States Department of Agriculture, Bulletin 197, December, 1910, P. 27.

"an especially adapted variety of soy bean used on the rice lands of Central China. These soy beans have been tested and give every promise of filling the need perfectly. . . . Thus we have a combination of crops which will, we hope, do for the rice grower what clover does for the wheat fields of the north. We have not only a valuable soil improver, but an important forage crop as well." (1)

Mr. C. V. Piper, in writing for the Yearbook in 1908, said:

"Fully two hundred varieties have now been obtained, showing a diversity of growth and of possible value wholly unsuspected. . . . The rapidly increasing prominence of the soy bean, especially in the southern states, makes it important to secure the very best possible varieties." (2)

The soybean did not secure real recognition until 1917. At the time of the war there was a shortage of cottonseed, and it was discovered the oil from the soybean could be substituted for cottonseed oil. This stimulated the growth considerably. Up to this time this versatile plant had only been used as a forage crop. There is a very lengthy discussion written by W. J. Morse in the Yearbook for 1917 on the value and the increased uses of the soybean. The first statistics on the production of soybeans in this country are for

(1) United States Department of Agriculture, Yearbook, 1907, P. 48.
(2) Piper, C. V., The Search for New Leguminous Forage Crops, United States Department of Agriculture, 1908, P. 257.

1907, when it was estimated that there were 50,000 acres planted. By 1917 this had increased to 500,000 acres. The production between the years 1918 and 1924 was fairly constant. The industry has grown steadily since 1924 as shown by the following table:

Table 1

Total Acreage, Production, and Farm Value of Soybeans 1924-1940

Year	Total Acreage 1,000 acres	Production 1,000 bu.	Farm Value $1,000
1924	1 782	4 947	$12 162
1925	1 785	4 875	11 430
1926	2 127	5 239	10 529
1927	2 350	6 938	12 562
1928	2 439	7 880	14 849
1929	2 736	9 398	17 621
1930	3 387	13 471	18 291
1931	4 194	16 733	8 183
1932	4 049	14 975	8 083
1933	3 777	13 147	12 268
1934	5 994	23 095	22 925
1935	7 111	44 378	32 295
1936	6 646	29 983	38 409
1937	7 005	45 272	38 178
1938	8 196	62 729	42 376
1939	10 489	91 272	74 299
1940	11 462	79 837	60 535

Source--United States Department of Agriculture, Agricultural Statistics, 1941, Table 392, P. 299, adapted.

Although the acreage for 1940 exceeded that of 1939, the crop harvested was smaller. This was due to poor weather conditions.

The recent estimate for the 1941 crop is

"113.3 million bushels--twenty million bushels over the previous record output in 1939, and thirty-one million bushels over the 1940 production." (1)

In the last twenty years the soybean has grown from a crop of minor importance to one of major importance. It now ranks fourth among the cereals. Production in 1939 was ten times what it was ten years earlier. There is no indication, as will be discussed later, that the production of soybeans has reached its peak. If the Government goal is reached, acreage will be increased in 1942 more than fifty per cent above the 1941 record crop.

(1) United States Department of Commerce, Industrial Reference Series, No. 91, November, 1941, P. 4.

LEADERS IN THE INDUSTRY

Recent writers give credit to a number of men for the rapid growth of the soybean industry in the United States. In an article in the September, 1940 issue of the <u>Readers' Digest</u>, Eugene Staley is given credit for the growth of the industry, while in the March, 1939 issue of the <u>Country Gentleman</u>, the following statement is made: "If there ever was a one man crop in this country, it is the soybean, and W. J. Morse is the man."(1) In all probability, there have been several men who have contributed to the development of the industry, as there have been economic factors and factors regarding the plant itself that have helped with the development. J. Sidney Cates in writing of the growing importance of soybeans says,

> "It is not a crop of chance--it is one of a few great American crops coming into its own by research, plant research, patient effort, and design." (2)

<u>W. J. Morse</u>

In the number of his Governmental publications and in the references to his work, it would seem that

(1) Cates, J. Sidney, <u>Big Time Performance for Soys</u>, Country Gentleman, Vol. 109, March, 1939, P. 23.
(2) Ibid. P. 23.

W. J. Morse of the Department of Agriculture has done a great deal in the development of the industry. C. V. Piper, head of Office of Forage Crops in Washington, selected Mr. Morse in 1907, then a local farm boy, to build a new crop plant for American field agriculture. At that time there was only a small industry in eastern North Carolina. When he started work in 1907, there were less than 50,000 acres planted to soybeans in the whole country. Since then Mr. Morse has put more than 10,000 different lots of beans imported from Japan, Chosen, Java, Sumatra, and India through the tests, and has selected the most promising-looking plants as a result of the findings. These lots represent over twenty-five hundred distinct varieties. It is from the single plant selections made by Morse that ninety per cent of the commercial soybean varieties has been developed today. In 1913, through these experiments, the first variety well adapted to the corn belt was introduced--the well-known Manchu. In 1931 Morse brought from the Orient a variety of bean that may be used as a green bean. This is a new type to this country, and had been overlooked before as it was known in the Orient by a different name. Since then Morse has developed seventy-five distinct garden vegetable varieties.

Eugene Staley

While Morse has worked on the improvement of the bean and its uses, the second man, Eugene Staley, has probably sold the idea to the farmers. In an article, Big Time Performance for Soys, written about Mr. Morse by J. Sidney Cates, it is mentioned that a missionary sent samples of the bean to a farmer in North Carolina. According to an article in Readers' Digest, September, 1940, written by Mr. D. Wharton, these beans were apparently received by Eugene Staley's father, who planted them and they were eaten as a vegetable by the family. When Staley was trying to find a way to replenish the cornfield soil, he thought of the soybean and remembered that it added nitrogen to the soil. He convinced some farmers that they should grow soybeans for this reason. In 1921 Staley and his associates built the first soybean mill in the United States, and they guaranteed the farmers they would buy all the soybeans they could grow. Mr. Wharton says this about his work with the farmers,

> ". . . He really went to work on Illinois farmers. He had salesmen talk to them in fields, in school rooms, and in courthouses. He sent out letters, pamphlets, newspapers, and farm journal articles." (1)

(1) Wharton, D., Soybean Pioneer, Readers' Digest, Vol. 38, September, 1941, P. 71.

In the fall of 1922 to March 1923, his mill had handled more than twice as many soybeans as the state had harvested the year before. This rapid development is related in the following statement from Mr. Wharton's article:

> "When Staley opened his mill he bought beans by the wagonload; in sixty days last fall, railroads brought 9400 cars of beans to the four processors in Decatur, which has now become the soybean capital of America. Staley, now 73, and the largest processor in the industry, couldn't get enough beans to make all the oil and meal he could sell." (1)

Eugene Staley died in December, 1940. His work is being carried on by his son, A. E. Staley, Jr., who is President of the A. E. Staley Manufacturing Company.

The Ford Industry

Henry Ford is sometimes called the "Number 1" soybean man in the United States, and there is no question but that the soybean is his "Number 1" agricultural product. Mr. Ford believes that "business is only exchange of goods. If we want the farmer to be our customer, we must find a way to be his customer." (1) He became interested in the soybean in 1930 and 1931, and

(1) Wharton, D., Soybean Pioneer, Readers' Digest, Vol. 38, September, 1941, P. 72.
(2) Sweinhard, James, Ford and the Coming Agrindustrial Age, April, 1940.

today is the largest single producer in the world. In 1930 experiments were made in Dearborn to determine which crop would most nearly fulfill the requirements of the "agrindustrial age." Experiments were made on wheat, carrots, sun flowers, cabbage, onions, corn stalks, and soybeans. One author states the extent of the experimental work as follows:

> "By December, 1931, $1,500,000 had been expended on these experiments and the soybean had been demonstrated to be the most adaptable to the needs of the Ford Plant." (1)

Three hundred varieties were tried and finally the Manchu and the Mandarin types were selected as the best varieties for use at the Ford Plant. By the end of 1941 nearly three million dollars had been spent on experiments with the soybean. In 1939 on his huge farms in Lenawee County, Michigan, Mr. Ford planted 5,797 acres to soybeans, which yielded nearly 82,366 bushels of soybeans. In addition to this he bought 350,000 bushels of soybeans and a large amount of soybean oil.

Under his treatment of a specially devised oil-extractor, one ton of beans yields four hundred pounds of oil and sixteen hundred pounds of meal. The oil is used in making enamel and core oil. Cores that are used

(1) Deasy, George F., Geography of the U. S. Soybean Oil Industry, The Journal of Geography, Vol. 40, January, 1941, P. 401.

in the molds in the foundry of the steel mill are made of soybean meal. The meal also goes to the Rouge Plant where it is made into plastic compound, and eventually goes into accelerator pedals, coil covers, and other parts of the Ford car.

Table 2
Uses of the Soybean in the Ford Motor Co.

Soybean Oil	Soybean Meal	Soybean Stalk
Enamels	Molded parts	Pressed board
Paints	Glues and adhesives	fiber
Varnishes	Water paint	Furfural
Linoleum	Core bond	
Oil Cloth	Plyewood glues	
Ink	Briquettes	
Glycerine	Paper sizing	
Stearic acid		
Soap		
Foundry sand		
Core		

Source--Deasy, George F., Geography of the U. S. Soybean Oil Industry, The Journal of Geography, Vol. 40, January, 1941, P. 403.

Synthetic wool from soybeans is used in the upholstery of Ford cars. Plastic has been developed so that it may be used for the entire body of a car. This plastic was first used in a trunk on one of Mr. Ford's cars. It proved to be so successful that preparations were being made for mass production in November, 1940. The plastic is supposed to withstand severe blows of an ax or a hammer. Test panels were made of seventy per cent cellulose fiber, thirty per cent resin binder, pressed into cloth. This was analyzed by one author as

follows:

> "Alone the cloth has little strength, but several sheets heat molded in a 1,000 ton press produces a material superior to steel in everything but tensile strength. It is fifty per cent lighter, fifty per cent cheaper, and ten times stronger." (1)

As the plastic does not have the tensile strength of steel, the frame and chassis would still be made of steel. The color of the plastic is not paint but has been inbedded in the material itself.

Before war was declared, it was expected that in the production of one million plastic automobiles, 50,000 tons of synthetic chemicals would be used and 170,000 tons of agricultural products. The products that would go into the manufacture might be:

> "100,000 bales of cotton, 500,000 bushels of wheat, 700,000 bushels of soybeans, 500,000 bushels of corn, lesser amounts of hides, lard, blue, pine pitch, sugar cane, alcohol, and flax." (2)

Aside from these products, to manufacture Ford cars, it would be necessary to import cork, rubber, tung oil, and ramie. It is possible to interchange the products wheat, corn, and soybeans. All three may be used or only one.

Besides being interested in the industrial

(1) Time, Plastic Fords, November 11, 1940, Vol. 26, P. 65.
(2) Ibid. P. 65.

uses of the soybean, the Ford scientists have not neglected the agricultural end. Experiments have been made with many varieties. Seed has been furnished to independent farmers to be grown for use in the Ford plants. The research engineers of the Ford Company have designed and built a model oil extractor to aid the farmers in marketing their soybeans. Mr. Ford has encouraged the farmers to extract their own oil in the winter months during their slack season and to use the meal left for feeding. In the last two years the Ford Motor Company has obtained more than ninety per cent of its soybeans from independent growers living within a distance of two hundred miles of Dearborn. The effect of this can best be shown by the following statement:

> "The number of farms in southern Michigan, northern Ohio, and northern Indiana has increased three hundred per cent under the stimulus of a ready market." (1)

The products that do not go into Ford cars--as the flakes--are treated in the Ford plant and sold as cattle and poultry feed and as fertilizer.

The man who is responsible for most of the experimental work on soybeans at the Ford plants is Robert Boyer. Henry Ford "discovered" Boyer in 1925

(1) Deasy, George F., Geography of the U. S. Soybean Oil Industry, The Journal of Geography, Vol. 40, January, 1941, P. 404.

while visiting his Wayside Inn, which was managed at that time by Robert Boyer's father. Ford took him out of the Framingham High School and enrolled him in the Ford Trade School. In 1930 Ford built him a temporary three story frame lab, which is still being used. Boyer now has twenty-eight assistants; there are now four soybean plants. Boyer received the United States Junior Chamber of Commerce Distinguished Service Award for 1940 for his work in developing the plastic body.

The University of Illinois Laboratory

In the early part of 1936 the Department of Agriculture established a soybean laboratory at the University of Illinois, under the provisions of the Bankhead-Jones Act. It is a cooperative organization in which participate the Bureaus of Agricultural Chemistry and Engineering, and Plant Industry of the United States Department of Agriculture, and the Agricultural Experiment Stations of the North Central States of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North and South Dakota, Ohio, and Wisconsin. The scientists there are working toward three objectives; (1) to find new ways of using soybeans in industry and to improve the applications already made, (2) to study the effects of different processes on

quality and quantity of soybean products, and (3) to work out better methods of testing different varieties of soybeans as to adaptability and industrial uses.

It may be of interest here, in order to give an idea of the scope of the work that has been accomplished at the University of Illinois, to list some of their publications:

> Eleven Years of Soybean Investigations--Varieties, Seeding, and Storage, January, 1940,
>
> Recent Developments in the Utilization of Soybean Oil in Paint, September, 1935,
>
> Range and Adaptation of Certain Varieties of Vegetable-Type Soybeans, December, 1940,
>
> Utilizing the Soybean Crop in Livestock Feeding, April, 1931,
>
> Plastic Materials from Farm Products, 1939,
>
> Soybeans--Their Effect on Soil Productivity, June, 1939,
>
> The Soybean--A Plant Immigrant Makes Good, September, 1936.

Dr. W. L. Burlison, head of the Agronomy Department at the University of Illinois, has been responsible for much of the work that has been done at the University of Illinois. Dr. Burlison became interested in the soybean while he was doing graduate work at the University of Illinois. At that time only one bulletin and one circular had been issued on soybeans as a "hard-time hay crop and soil builder." Soybean breeding experiments

had just started at the state experimental station.

Dr. T. H. Hopper is now director of the laboratory, having taken over the duties May 1, 1941. Since its inauguration, the laboratory has had three directors--Dr. O. E. May, Dr. R. T. Milner, and Dr. Hopper. Dr. Milner resigned his position as director to be a research chemist at the United States Regional Agricultural Byproducts Laboratory at Peoria, Illinois. Dr. May is head of the research work there.

The American Soybean Association

The American Soybean Association is of growing importance in the development of the soybean industry. The organization of the association is described in an editorial written for Soybean Digest, November, 1940:

> "The first movement to organize the soybean interests of America dates back to September 3, 1920 at a mammoth soybean meeting held on the Soyland Farms, owned by the Fouts Brothers, Camden, Indiana. This meeting was called under the auspices of the Purdue Extension Department, primarily for the purpose of acquainting corn belt farmers with the virtues of this new crop. . . . The enthusiasm aroused by the possibilities of the crop expressed itself at this first meeting in the formation of an organization which was named, 'The National Soybean Growers' Association.' " (1)

(1) Soybean Digest, The, Behind the Scenes, Vol 1, November, 1940, P. 2.

Later, in 1925, the name of this organization was changed to "The American Soybean Association." When originally organized the association was mainly for growers. During the past twenty years it has broadened its activities to include marketing, processing, and utilization of the product. This is brought out by one author as follows,

> "It is obviously no longer necessary for this organization to encourage greater acreages of soybeans; instead, the problem now is one of developing a continuously expanding market through industrial processes that may absorb these increasing supplies." (1)

The American Soybean Association has entered the legislative field, and in cooperation with other organizations, was instrumental in having the $6.00 per ton tariff levied on imported soybean cake and meal. It assisted in the enactment of the "Bailey Amendment" to the 1936 Revenue Bill, which levied a processing tax of from three to five cents per pound on the chief foreign oils imported for processing.

In November, 1940 the American Soybean Association issued the first copy of the <u>Soybean Digest</u>, a monthly publication.

Credit must be given to all state experiment

(1) Soybean Digest, The, <u>Behind the Scenes</u>, Vol. 1, November, 1940, P. 2.

stations for playing a very large part in the development of the soybean industry in the United States. Most states, where the crop is grown to any extent, have experimented, made tests, and are able to inform the farmer what varieties are most suitable for his particular locality. Even though states do not produce large quantities, the state departments have done experimental work. New Hampshire does not produce enough to be listed in the United States Department of Agriculture Statistical Report, but the New Hampshire Agriculture Experiment Station published a pamphlet in January, 1941, entitled, Soybeans in New Hampshire, in which it is stated that "because of their high feeding value, there seem to be some good reasons why more soybeans might be grown on New Hampshire farms." (1)

It is impossible here to give everyone credit who has assisted in the development of this industry. Many of the assistants of the scientists at the head of experimental work throughout the country have played a very important roll. R. W. Howard, writing for the Farm Journal and Farmer's Wife, has this to say about the men who have been responsible for the rapid growth

(1) Prince, Ford S., Higgins, L. J., Blood, Paul T., and Percival, G. P., Soybeans in New Hampshire, January, 1941, P. 5.

of the industry:

". . . The soy had a succession of American step-fathers. Dr. W. J. Morse of the U. S. Department of Agriculture went to China and brought back new varieties. Dr. Burlison and co-workers discovered that soys when correctly handled can be made a soil-building crop and that the soy plant is immune to chinch bugs and dry weather. Finally, in 1928, H. J. Atwood of Allied Mills established an industrial market for the bean by contracting, with the support of the Funk Brothers Seed Co. and the Grange League Federation, for 50,000 acres of the year's crop at $1.45 per bushel. Add to this small list the Fout Brothers Farm in Indiana, the Glenn McIlroy and Johnson Brothers farms in Ohio, the plant breeders and agronomists of Purdue, Ohio State, Wisconsin, Iowa, and Missouri, plus the lean, prying figure of Henry Ford. Then salute the combine-harvester, and you have the step-daddies who turned this Abie's Irish Rose of agriculture into a smash hit that has done more than any other single crop to bring Farm, Science, and Industry to the same conference table." (1)

In September, 1941 "Soybean Day" on the University of Illinois campus was celebrated. At the banquet Dr. Burlison gave credit to another group of men--the pioneers of the soybean industry, men who had grown soybeans before 1914.

"Dr. Burlison nodded down at the 40 pioneers. He switched on the microphone. 'These . . . were the utterly follish dreamers.' . . . Out on the black prairie, the ripe soys

(1) Howard, R. W., Little Beans, Big Business, Farm Journal and Farmer's Wife, Vol. 65, November, 1941, P. 19.

> "rustled and scrambled in the wet wind. It was Americanization Night for an immigrant bean." (1)

Soybean Trains

The soybean trains may be of minor importance in the growth of the soybean industry, but they have, nevertheless, been a means of stimulating interest. There have been two--the first in 1937, which was sponsored by two national associations of producers and of processors. Characterized as "soybean products from the roof to the rails," an air-conditioned coach of the Pennsylvania Railroad, housing an exhibition and equipment for the demonstration of the uses and method of production of the soybean, left New Jersey on August 16 for a month's tour through New Jersey, Pennsylvania, Ohio, Indiana, and Illinois to make a total of twenty-five stops. Many of the parts of the car were finished with soybean products--the roof was painted brown with soybean paint; the exterior was finished with soybean varnish. The door knobs and exhibit cases in the interior of the car were products of the soybean. The glue used in constructing the plywood finishes was also made

(1) Howard, R. W., Little Beans, Big Business, Farm Journal and Farmer's Wife, Vol. 65, November, 1941, P. 19.

from soybeans. In the foundry, soybean oil was mixed with core sand used in the casting.

The second train, in charge of O. K. Quivey, Manager of Agricultural Development for the Baltimore and Ohio, and operated in conjunction with Ohio, Purdue, and Illinois Universities, left Baltimore in February, 1941, for a tour of Ohio, Indiana, and Illinois. It made fifty-one stops in as many cities and towns, and was visited by 19,558 people, or an average of 383 per stop. Aneta Beadle Vogler, formerly nutrition specialist for Purdue University, conducted a soybean cooking school on the train. Mr. Quivey, who was in charge of the train, wrote this about the accomplishments of the trip,

> "The Soybean Special went the full way in giving information regarding the best adaptable varieties and seed sources, seedbed preparation, planting, cultivation, harvesting, rotation, marketing, processing, and utilization." (1)

(1) Quivey, O. K., Soybean Special Ends Three-State Tour, The Soybean Digest, Volume 1, April, 1941, P. 4.

CHARACTERISTICS OF THE BEAN

The soybean plant has desirable characteristics that have been important in its growth in this country. The most important of these factors are:

1. It is a good soil builder crop
2. It can be grown as a cash crop
3. It is relatively free from the chinch bug and crop pests
4. Farmers have found it to be a good substitute for oats
5. It has a comparatively short growing period and may be planted after some other crop has frozen out
6. It can withstand severe drought, usually doing well wherever a good seedbed can be prepared, even in seasons too dry for alfalfa or clover to survive
7. It has wide climate adaptability
8. It can be harvested with a small combine
9. It may be harvested in the fall after other crops have been cared for
10. Tractors have replaced horses in many sections, and it is easier to harvest soybeans than oats with a tractor
11. They serve well as a pasture crop.

When it is stated that soybeans are a good soil builder crop it is meant that they add nitrogen to the soil. Perhaps this value has been overestimated. Experiments at the University of Illinois have shown that under the best conditions soybeans can obtain about

two-thirds of their nitrogen from the air; the other one-third must be obtained from the soil itself. The extent of the nitrogen added to the soil is given by Mr. O. H. Sears of the University of Illinois, as follows:

> "Furthermore, the soybean plant has a comparatively small root system, about nine-tenths of the plant being above the ground. The amount of nitrogen obtained in the tops is therefore greater than the amount secured from the air; and consequently when all the above-ground parts of the plant are harvested from the land, no nitrogen is added to the soil by the soybeans." (1)

The amount of nitrogen added to the soil depends upon the use that is made of the soybean crop. From the findings of the Research Department of the University of Illinois, if well-modulated soybeans are plowed under as green manure, considerable nitrogen is added--in fact, on the basis of a yield of twenty bushels or 4500 pounds of hay, eighty-eight pounds of nitrogen per acre are added. On the same basis, if the hay is returned to the soil and plowed under, twenty-six pounds are added to each acre; if a combine thresher is used and the straw is left in the field, sixteen pounds per acre. If the seed is harvested and the straw is not

(1) Sears, O. H., Soybeans, <u>Their Effect on Soil Productivity</u>, University of Illinois, Bulletin 456, June, 1939, P. 552.

returned, there will be a loss of nitrogen from the soil. It is often stated that soybeans are a better soil-builder crop than alfalfa. Mr. Sears offers the following contradiction to that statement,

> "Because a smaller proportion of the soybean plant than of the alfalfa plant consists of roots, and because soybeans make no fall growth to replace the loss incurred when the tops are removed, it is even more important in building up the nitrogen balance in the soil with soybeans, than when building it with alfalfa, to return a substantial portion of the tops to the soil either as green manure or as livestock manure." (1)

As soybeans tend to add nitrogen to the soil and, at the same time improve the tilth, the microorganic population is increased.

> "The improvement in physical condition is, without doubt, favorable to the development of microorganisms, particularly those requiring plenty of oxygen." (2)

In an experiment where corn was planted three successive years on land where soybeans had been grown, the yield was greatest the first year, and then decreased each following year. Also, the microorganic population decreased each year corn was planted.

Although soybeans do improve the tilth of the land, at the same time they cause the soil to erode

(1) Sears, O. H., Soybeans, Their Effect on Soil Productivity, University of Illinois, Bulletin 456, June, 1939, P. 554.
(2) Ibid. P. 557.

easily. If the beans are planted solid and across the slope, erosion is reduced. This, however, does create a problem of controlling weeds. A recent revision in the AAA program refers to soil erosion:

> ". . . in states having a minimum acreage requirement of soil conserving or erosion resisting crops on each farm, soybeans grown for any purpose will be classified as erosion resisting crop. Previously soybeans from which seed was harvested by mechanical means were not so classified." (1)

Another bad effect soybeans have on the soil is they draw heavily on minerals. If the straw is returned to the soil, soybeans remove slightly more phosphorus, calcium, and magnesium than corn. If the crop is sold for hay, twice as much phosphorus and five times as much potassium are removed compared with an average crop of corn. On the other hand, a soybean crop does not remove any more minerals than alfalfa. Quoting Mr. Sears again, the danger of mineral depletion may be summarized as follows:

> "It is certain, however, that the continued growing of large crops of soybeans for market purposes will gradually but surely deplete the soil of those mineral elements in which it is rich--just as will the growing of any other crop for a similar purpose. If profitable yields are to be maintained, it will become necessary sooner or later, depending

(1) Business Week, <u>Soybean Paradox</u>, June 21, 1941 P. 62.

"upon the characteristics of the individual soil, to return to the land the phosphate, potash, and lime taken off by the crops." (1)

The chinch bug does not feed on soybeans, and they do less damage to corn if soybeans are planted with the corn. Soybeans usually are comparatively free from serious insect pests. Those that seriously injure the plant are grasshoppers, blister beetles, leafhoppers, the green clover worm, and the velvetbean caterpillar.

"Although the soybean is affected by several destructive diseases in Asiatic countries, no disease of this plant has yet assumed any great economic importance in the United States. It is attacked here, however, by fungus, bacterial and virus diseases. . . Undoubtedly, failure to give due recognition to the prevalence of these diseases may cause severe losses as the seed sources become more highly infested." (2)

The diseases listed by Mr. Morse that may cause damage to soybeans are: purple spot, bacterial blight, bacterial pustule, mosaic, fusarium blight or wilt disease, frog-eye leaf spot, brown spot, sunburn, downy mildew, pod and stem blight, anthracnose stem rot, phythium root rot and root knot. Methods of treatment vary for each disease. Effective sprays and dusting powders

(1) Sears, O. H., Soybeans, Their Effect on Soil Productivity, University of Illinois, Bulletin 456, June, 1939, P. 55.
(2) Morse, W. J., Cartter, J. L., Soybeans--Culture and Varieties, U.S.D.A., Bulletin No. 1520, November, 1939, P. 33.

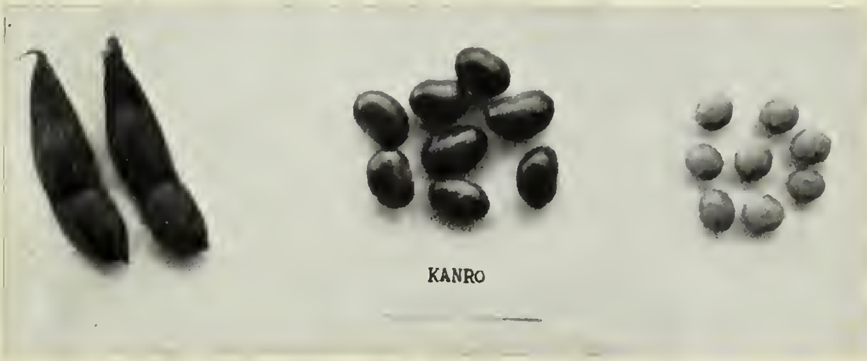
for treating diseases are given by Mr. Morse in the publication, Soybeans: Culture and Varieties. These diseases affect different parts of the plant, and a disease that may occur in the middle west, will not necessarily occur in some other section of the United States.

When the Department of Agriculture first wrote of the soybean, it warned that the plant would not survive where rabbits are prevalent. Woodchucks have caused damage in the northern states; deer have done damage in some sections. Pheasants have done considerable damage in South Dakota.

VARIETIES

Description of the Plant

A Soybean Test Plot



Pods, Green Beans, and Mature Beans of
a Vegetable Variety

The soybean ranges in size from a little more than a foot to six feet, although, generally speaking, it averages from two to three feet. Dr. Burlison describes the plant as follows:

> "The soybean is a summer leguminous annual. Pods are from one to two and one-half inches long and contain from two to four seeds. The stems, leaves, and seed pods are covered with short reddish-brown or gray hairs. The root tubercles are large and abundant. . . . The flowers are small and inconspicuous, either white or purple, and are clustered in the axils of the leaves. The stems are branched, rather woody, and grow from two to three and one-half feet or more in height." (1)

Name

The soybean has been given under a variety of botanical names since it first appeared in literature. In 1794, Moench, in describing the plant called it "soja hispida"; Savi, in 1829, writes of it as "Soja japonica"; Miquel in 1855, "Soja angustifolia"; Maximowicz in 1873, "Glycine hispida". "Under existing botanical rules, the soybean which is known only as cultivated has been called "Glycine hispida". (2) In more recent writings it is called "Soja max".

(1) Burlison, W. L., A Plant Immigrant Makes Good, Univ. of Ill., September, 1936, Pp.3-4.
(2) Piper, C. V., Morse, W. J., The Soy Bean: History, Varieties and Field Studies, U.S.D.A., December 31, 1910, P. 9.

Just as botanical names have gone through a series of changes, so has the common name. The Chinese called it "Shi Yu", "Shi" meaning the salted bean and "Yu" referring to the sauce or condiment. The name "soy" supposedly comes from the Japanese word "Shoya", which means a food prepared from seeds. When Perry brought seeds from Japan, they were called "Japan peas", and soybeans were called by this name for a number of years in the United States. Later writers called it "soja bean", then "soya bean", (it is now called "soya" in Germany), then "soy bean", and in recent years, all leading writers in the field have shortened it to one word, "soybean".

Classification of Varieties

The beans are classified as to color--yellow, green, brown, black, and mixed. Authorities give seeds adapted for various uses as follows:

> "Varieties for seed production are preferably the yellow-seeded types, which are used for processing for oil, oil meal, and flour, but these varieties may be used also for forage purposes if heavier rates of seeding are used. Forage types are generally those with black or brown seeds, and are for the most part smaller seeded, finer stemmed, and more leafy, and they contain less oil than the yellow-seeded varieties. For dry edible beans or green shelled beans, the most suitable varieties are those with straw-yellow or olive-yellow seed. . . . The varieties used for processing usually

> "do not cook easily and have a raw beany flavor. A few black, brown, and bicolored varieties have been found to have superior qualities as green shelled beans." (1)

Studies of varieties have been intensive and productive. Up to 1907 only five or six varieties were known in this country. Then W. J. Morse of the United States Department of Agriculture started working on varieties. By 1908 two hundred varieties had been obtained and investigated. All of the new varieties that were obtained at that time came from single localities. It is believed that this is due to the fact that throughout the Chinese Empire every variety was grown locally. This localization is described in a Yearbook of the United States Department of Agriculture in the following terms:

> "Mr. F. N. Meyer, who has traveled widely in China, states that this extreme localization of these varieties is a very striking fact in Chinese agriculture, due, as he thinks, to the fact, that for ages every Chinese farmer has grown his own seed, and there has been little or no exchange of seeds from province to province. It would therefore appear likely that numerous other varieties yet remain to be obtained." (2)

More varieties were introduced and tested. By 1917 more than five hundred distinct varieties had

(1) Morse, W. J., Cartter, J. L., Soybeans: Culture and Varieties, U.S.D.A., November, 1939, P. 6.
(2) United States Department of Agriculture, Yearbook, Report of the Secretary, 1908, P. 257.

been grown by the Department of Agriculture on its testing grounds and twenty varieties were handled commercially by growers. It is estimated that at least ten thousand lots have been put through the tests. At the present time over one hundred named varieties are grown in this country. W. J. Morse and J. L. Cartter list (1) some one hundred and twenty-seven with full descriptions of each variety.

In most classifications of varieties, soybeans are listed as to use and growing season. The Department of Agriculture recommends the following for growing in this country:

Table 3

Varieties of Soybeans Recommended for Different Uses

Very early (100 days or less):		
	Seed.	Cayuga, Mandarin, Minsoy.
	Forage.	Cayuga, Chernie, Ogemaw, Soysota, Wisconsin Black.
	Green Vegetable . .	Agate, Sious.
Early (101 to 110 days):		
	Seed.	A. K., Aksarben, Dunfield, Elton, Habaro, Hoosier Illini, Ito San, Manchu, Mandell, Mukden, Pinpu, Richland, Wea.
	Forage.	A. K., Black Eyebrow, Chestnut.

(1) Morse, W. J., Cartter, J. L., Soybeans: Culture and Varieties, U.S.D.A., November, 1939, Pp. 7-17.

Table 3 Con't

Varieties of Soybeans Recommended for Different Uses

	Green Vegetable . .	Bansei, Chusei, Goku, Kanro, Waseda.
	Dry Edible.	Bansei, Chusei, Goku, Kanro, Waseda.
Medium early (111 to 120 days):		
	Seed.	Harbnisoy, Hongkong, Mansoy, Midwest, Sciota.
	Forage.	Harbinsoy, Ilsoy, Medium Green.
	Green Vegetable . .	Fuji, Hakote, Hiro, Hokkaido, Jogun, Jura, Osaya, Sato, Shiro, Sousei, Suru, Toku, Willomi.
	Dry Edible.	Hokkaido, Jogun, Csaya, Sousei, Suru, Toku, Willomi.
Medium (121 to 130 days):		
	Seed.	Hurrelbrink, Macoupin, Yokoten.
	Forage.	Columbia, Ebony, Kingwa, Lexington, Norredo, Ozark, Peking, Pine Dell Perfection, Sooty, Virginia, Wilson, Wilson-Five.
	Green Vegetable . .	Chame, Funk Delicious, Imperial.
	Dry Edible.	Funk Delicious, Imperial.
Medium late (131 to 140 days):		
	Seed.	Arksoy, Chiquita, Dixie, Easycook, Haberlandt, Herman, Hollybrook, Morse, Southern Prolific, Tokyo, Wood's Yellow.
	Forage.	Chiquita, George Washington, Laredo, Mammoth Brown, Old Dominion, Tarheel Black.
	Green Vegetable . .	Aoda, Hahto, Higan, Rokusun.
	Dry Edible.	Easycook, Haberlandt, Higan, Rokusun, Tokyo.

Table 3 Con't

Varieties of Soybeans Recommended for Different Uses

Late (141 to 160 days):		
	Seed.	Clemson, Delsta, Hayseed, Mamloxi, Mammoth Yellow, Mamredo, Missoy.
	Forage.	Barchet, Clemson, Hayseed, Missoy, Pee Dee, Southern Green.
	Green Vegetable . .	Nanda
	Dry Edible	Nanda
Very late (161 or more days):		
	Seed.	Charlee, Creole, Delnoshat, Georgian, Monetta, Nanking, Palmetto, White Biloxi, Yelredo.
	Forage.	Avoyelles, Biloxi, Charlee, Creole, Georgian, Monetta, Oloxi, Otootan, Palmetto, Yelredo.

Source--Morse, W. J., Cartter, J. L., Soybeans: Culture and Varieties, U.S.D.A., November, 1939, Pp 6-7.

When it is taken into consideration just how much is involved to get results on one variety, the amount of work entailed in the selection of these varieties will be appreciated. State departments have also experimented extensively in varieties that are suitable for each state and all sections of each state. The University of Illinois scientists have published a booklet, Eleven Years of Soybean Investigations, in which they give their results of numerous tests on varieties and have made recommendations for varieties for northern, central, and southern Illinois. These scientists say, "the rec-

ommendations are based not only on quantity, yields, but also on performance in such other respects as shattering, lodging, color of bean, and time required for maturing." (1) Yields and general performance of approximately sixty-five varieties and strains of soybeans were tested. The University of Illinois has also experimented on the adaptation of vegetable varieties of soybeans. Samples were sent out to all parts of the United States. Answers were received from 810 persons. As a result of these findings, Mr. Lloyd of the University of Illinois writes, "Successful production was reported from Maine to the Pacific Coast, and from near sea level to an altitude of 8,000 feet." (2) About seventy per cent of the persons reporting success in the production of the crop were well pleased with the table quality of the soybean. As well as trying these experiments in the United States, attempts were made to grow the vegetable variety in Newfoundland, Mexico, and Honolulu. In Newfoundland the plants grew very well but had not blossomed when killed by frost in August. In Mexico where it was very hot the beans did not develop seeds. In Hawaii

(1) Burlison, W. L., Van Doren, C. A., Hackelman, J. C., Eleven Years of Soybean Investigations, January, 1940, P. 163.
(2) Lloyd, J. N., Range of Adaptation of Certain Varieties of Vegetable Type Soybeans, Univ. of Ill., December, 1940, P. 100.

the plants yielded very well although they grew only twelve to fourteen inches high.

There are a number of important considerations in the selection of seed. The most important of these is the adaptation to local climatic and soil conditions. State Departments are prepared to make local recommendations. The yield of forage or of seed must be considered; the habit of growth, maturity, coarseness, ability to retain leaves, color and size of seeds, shattering, and disease resistance are all important. Now that more soybeans are going into industry, it is important to consider the product that is to be manufactured.

New varieties are being advertised constantly in trade magazines. Every field, no matter how pure the seed has been, has freak plants that possess distinctly different varietal characteristics. Through the selection and multiplication of these plants, many new varieties have been developed. The latest development in selection of varieties is in hybridization. George M. Strayer, Editor of The Soybean Digest, has the following to say regarding this:

> "The program of soybean hybridization to produce better varieties is gathering momentum in our state agricultural experiment stations and an enormous amount of work in this line is being done by the United States Regional Soybean Industrial Products Laboratory. Little doubt exists but that this work will

> "produce improvements in soybean varieties comparable to the strides made in oats and wheat varieties in recent years and in the hybrid seed corn development.
>
> But hybridization, followed by several seasons of selection with no guarantee even then that a superior variety will be found, requires many seasons of work and we can look for little help this year or next, or even the year after that, for new varieties still in our research greenhouses.
>
> Thus our immediate hope by a long process of elimination lies inescapably in better culture methods." (1)

Grades of Soybeans

New grades for soybeans went into effect September 1, 1941. The standards before this had been in effect under the Grain Standards Act since November 20, 1940, and had been in effect as permissive standards for five years prior to that date. The need for changes was made apparent through a study of the distribution of soybeans marketed among different grades. Only two per cent of the soybeans were graded No. 1, thirty-five per cent No. 2, and forty-five per cent No. 3. No. 1 grade was of little practical use. Under the proposed new standards it was expected that approximately eleven per cent would grade No. 1, thirty-five per cent No. 2,

(1) Strayer, George M., Editorial, The Soybean Digest, Volume 1, April, 1941, P. 6.

and thirty-five per cent No. 3.

The new system of grading is:

Table 4

Grade requirements for Yellow Soybeans, Green Soybeans, Brown Soybeans, Black Soybeans, and Mixed Soybeans.

Grade No.	Minimum Test Weight per Bushel Lbs.	Moisture Pct.	Splits Pct.	Damaged Kernels Soybeans and Other Grains Pct.	Foreign Material Other Than Dockage Pct.
1*	56	13	10	2	1
2*	54	14	15	3	2
3	52	16	20	5	3
4**	49	18	30	8	5

* The soybeans in Grade No. 1 of each of the classes Yellow Soybeans and Green Soybeans may contain not more than 2 per cent, and the soybeans in Grade No. 2 of each of these classes may contain not more than 3 per cent of Black, Brown, or Bicolored soybeans, singly or combined.

** Soybeans that are badly weathered or badly stained shall not be graded higher than No. 4.

Source--Flumerfelt, Walter, The New Soybean Grades, The Soybean Digest, September, 1941, P. 9.

It is expected that all processors will grade more closely as prices increase.

DISTRIBUTION OF PRODUCTION

Soybeans were first introduced in the New England states. They were later used in the south as a cover crop. Since the rapid increase in production, the main producing states have shifted from New England and the south to the middle west. They have been grown in practically every state in the union. Twenty-eight states are listed in the United States Department Statistical Report for 1941. They are given on the following page, arranged in the order of their production. It may be noted that the four leading states, Illinois, Iowa, Indiana, and Ohio produced 87.11 per cent of the total.

Other states produce soybeans to a limited extent, but not in sufficient quantities to be included in this table. There are a few grown in the New England states. A circular was issued by the New Hampshire Agricultural Experiment Station in January, 1941, in which the following is stated:

> "The soybean has proved to be an extremely useful crop on many New Hampshire farms. Thus far, the crop has been grown almost wholly for forage and utilized as green feed, pasture, hay, or silage. The acreage annually produced fluctuates to some extent depending upon individual farm needs but has reached a total of 3500 acres during certain seasons in the last decade. Very little soybean seed has been

Table 5

Soybean Acreage, Production, and Per Cent of Production by States, 1940.

State	Total Acreage 1,000 acres	Production 1,000 bu.	Per Cent of Total
Illinois	3 065	35 140	44.01%
Iowa	1 559	15 026	18.82
Indiana	1 508	10 989	13.76
Ohio	1 037	8 400	10.52
North Carolina	546	2 282	2.86
Missouri	480	1 176	1.47
Michigan	210	1 176	1.47
Mississippi	530	850	1.06
Wisconsin	311	648	.81
Minnesota	242	640	.80
Arkansas	284	570	.71
Virginia	141	480	.60
Delaware	44	364	.46
Kansas	78	312	.39
Tennessee	250	264	.33
Pennsylvania	79	255	.32
Kentucky	178	242	.30
Louisiana	239	234	.29
Maryland	50	216	.27
New York	16	140	.18
Alabama	263	99	.13
New Jersey	35	90	.11
South Carolina	70	78	.10
Georgia	113	78	.10
Texas	41	45	.06
Oklahoma	18	30	.04
W. Virginia	55	13	.03
Nebraska	20	--	--
United States	11 462	79 837	100.00

Source--United States Department of Agriculture, *Agricultural Statistics*, 1941, Page 300, adapted.

> "produced in New Hampshire. . . None of the New England states have, as yet, produced enough soybean seed to enter commercial channels to any extent." (1)

The writers of the above article give some of the reasons why New England farmers have not found it desirable to go into soybean seed production on a large scale. These reasons are:

1. The acre value of the seed crop after it is produced is relatively small; lower than it is for most other cash crops at their disposal.

2. Soybeans appear to render soils more susceptible to erosion. "Since we are now becoming more or less erosion conscious in this area it would seem that the introduction of soybeans on a large scale would be contrary to an already established trend of keeping more of our land in grass." (2)

3. Lack of harvesting and threshing machinery.

4. There are no nearby oil extraction plants.

These writers also believe that for the New Hampshire farmer, a soybean crop is of more value harvested as hay, or using the seed for feed, than it would be selling the crop for seed.

(1) Prince, Ford S., Higgins, L. J., Blood, Paul T., and Percival, G. P., Soybeans in New Hampshire, January, 1941, Pp. 3-4.
(2) Ibid. P. 4.

"And since most farmers, whether they know it or not, are feeding soybean meal to their livestock, it is not economical to grow beans and send them away to the processing plant, then have the meal shipped back again and pay freight in both directions." (1)

Because of the high feeding value of soybeans, it seems that more soybeans could be grown to an advantage on New England farms. Those farmers who already produce their own grain could provide a better ration for their dairy cattle if they would include soybeans.

State Disposition of Soybeans

Although disposition of the farm crop is taken up at another point in this paper, (see page 74), it may be of interest here to show how each state disposes of its crops. This will account to some extent for the differences in acreage planted and bushels produced, as well as differences in the yield per acre. Taking the statistics from Crops and Markets, published by the United States Department of Agriculture, these figures are changed to per cents instead of acreage, and will show the per cent of acres planted that is harvested for beans, the per cent that is cut for hay, and the per cent that is grazed or plowed under. These figures are

(1) Prince, Ford S., Higgins, L. J., Blood, Pault T., and Percival, G. P., Soybeans in New Hampshire, January, 1941, P. 5.

for 1940, and are based on the same acreage figures that are given on page 47 of this paper.

Table 6

Per Cent of Soybean Acreage Cut for Beans, Per Cent Harvested for Hay, and Per Cent Grazed or Plowed Under, 1940

State	% Soybeans for Beans	% Soybeans for Hay	% Soybeans Grazed or Plowed Under
Illinois	65.5	25.5	9.0
Iowa	47.0	49.0	4.0
Indiana	54.0	30.0	16.0
Ohio	54.1	35.1	10.8
N. Carolina	31.0	37.1	31.9
Missouri	23.3	66.3	10.4
Michigan	40.0	33.8	26.2
Mississippi	16.0	61.9	22.1
Wisconsin	12.0	79.0	9.0
Minnesota	16.5	79.3	4.2
Arkansas	21.1	60.9	18.0
Virginia	22.0	60.3	17.7
Delaware	59.1	29.5	11.4
Kansas	30.8	59.0	10.2
Tennessee	12.4	50.0	37.6
Pennsylvania	19.0	65.8	15.2
Kentucky	11.8	65.2	23.0
Louisiana	10.9	40.2	48.9
Maryland	32.0	52.0	16.0
New York	62.5	18.7	18.8
Alabama	6.8	82.1	11.1
New Jersey	17.1	37.1	45.8
S. Carolina	18.6	41.4	40.0
Georgia	10.6	70.8	18.6
W. Virginia	1.8	87.3	10.9
Texas	14.6	39.0	46.4
Oklahoma	16.6	38.9	44.5
Nebraska		100.0	
United States	43.3	42.6	14.1

It will be noted by this table that the states which are the largest producers, cut a larger per cent for beans. Some states on the eastern sea coast also cut quite a large per cent for beans. This is probably due to the fact that these states are located in industrial centers. Comparatively speaking, quite a large per cent of the southern crop is grazed or plowed under.

INCREASE IN PER ACRE PRODUCTION

Through research, development, and introduction of new varieties, the per acre yield has steadily improved. This is an important factor in the increased production in the United States. The increase in yield is indicated by the following table:

Table 7

Yield of Soybeans Per Acre, 1924-1940

Year	Yield Per Acre--Bu.
1924	11.0
1925	11.7
1926	11.2
1927	12.2
1928	13.6
1929	13.3
1930	13.4
1931	15.2
1932	15.3
1933	13.2
1934	15.0
1935	16.5
1936	14.1
1937	17.8
1938	20.2
1939	20.7
1940	16.1

Source--United States Department of Agriculture, *Agricultural Statistics*, 1941, P. 299, adapted.

The low yield in 1940 is attributed to dry weather. The crop for 1941, although not included in this table,

is estimated to be a "bumper crop" with good yields throughout the middle west. Some states produce more beans to the acre than others. As the yield per acre depends largely on local weather conditions, and may vary from year to year, a table is given for the ten year period of each producing state from 1929 to 1938 and the 1939 and 1940 yields.

Table 8

Soybean Per Acre Yield by States, Average 1929-1938; 1939, and 1940.

State	Av. 1929-38	1939	1940
New York	14.9	14.0	14.0
New Jersey	*	17.0	15.0
Pennsylvania	16.3	15.5	17.0
Ohio	17.4	21.0	15.0
Indiana	16.2	19.5	13.5
Illinois	18.4	24.5	17.5
Michigan	12.4	16.0	14.0
Wisconsin	12.0	16.0	17.5
Minnesota	*	17.0	16.0
Iowa	16.4	20.5	20.5
Missouri	8.0	10.0	10.5
Kansas	7.5	8.0	13.0
Delaware	13.4	15.5	14.0
Maryland	12.5	13.5	13.5
Virginia	12.0	15.0	15.5
W. Virginia	11.6	12.0	13.0
N. Carolina	12.4	12.5	13.5
S. Carolina	6.4	6.5	6.0
Georgia	5.8	6.1	6.5
Kentucky	10.2	12.0	11.5
Tennessee	7.3	7.2	8.5
Alabama	5.7	6.0	5.5
Mississippi	8.2	9.0	10.0
Arkansas	8.6	9.5	9.5
Louisiana	8.0	9.0	9.0
Oklahoma	8.4	8.0	10.0
Texas	7.6	5.5	7.5
United States	15.4	20.7	16.1

*--Not Available

Source--U. S. D. A., *Agricultural Statistics*, 1941, P.300

Generally speaking, the yields of the "corn belt section" exceed those of other sections of the country. The climate and soil of the north central states seem to be particularly well adapted to the growing of soybeans.

PRICES

Yearly Averages

"The price problem as we see it in the country grain trade is the biggest puzzle facing the farmer as he lays his planting plans each spring," (1) writes Max Belz of the Holland Grain Company, of Holland, Iowa. In discussing how prices affect the planting of soybeans, Mr. Belz tells how many of the farmers sold their previous year's crop at sixty cents a bushel, only to watch the market climb dizzily to a dollar and sixty cents.

In view of continued increased production, it would seem that farmers have been more or less satisfied that their crop would bring a fair return in comparison with other crops they might plant. The season's average price per bushel for the period 1930-1940 has been:

Table 9
Average Price Per Bushel of Soybeans, 1930-1940.

Year Beginning October	Average Season Price
1930	$1.36
1931	.49
1932	.54
1933	.93
1934	.99
1935	.73
1936	1.38
1937	.84
1938	.68
1939	.81
1940	.76

Source--U. S. D. A., Agricultural Statistics, P. 302

(1) Belz, Max, Farmers Resent Market Fluctuations, The Soybean Digest, Vol. 1, September, 1941, P. 16.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

There is no question but that the average price for 1941 will be well above the figures for the past few years. The following statements from official sources would seem to bear this out:

> "The attractive market for edible oils. . . raised the price of soybean futures to over $2.00 a bushel." (1)

> "Soybean futures rose to a record high of $2.02 a bushel early in September following the Secretary of Agriculture's statement asking for a greatly increased production of this oilseed in the food and defense program. . . Buyers were hesitant to purchase beans at the sharp price rise, which could not be equalized in crude oil sales. . . . However the farm price for soybeans from the new crop is more than double that of a year earlier." (2)

> "The farm price of soybeans in mid-September at $1.61 per bushel was more than double that of a year earlier. In mid-October the price in surplus producing areas was reported at $1.45 compared with a November price of sixty-five cents a year ago." (3)

Factors Affecting the Price

"Three important factors directly influence

(1) Lund, Charles E., Dept. of Commerce, Industrial Reference Series, Foodstuffs, No. 74, September, 1941, P. 5.
(2) Lund, Charles E., Dept. of Commerce, Industrial Reference Series, Foodstuffs, No. 82, October, 1941, P. 11.
(3) Lund, Charles E., Dept. of Commerce, Industrial Reference Series, Foodstuffs, No. 91, November, 1941, P. 4.

soybean prices--the price of soybean meal, the price of soybean oil, and the demand of soybeans as seed." (1) In order to compare the price of meal, oil, and soybean prices, the writer is including the price of each for the ten year period 1931-1940.

Table 10

Average Price of Soybean Seed, Oil, and Meal 1931-1940

Year	Soybeans Av. Price Per Bu.	Soybean Oil, Domestic Crude, Av. Price Per Lb. in Drums	Soybean Meal Av. Price Per Ton
1931	.49	$4.62	$32.52
1932	.54	5.84	20.83
1933	.93	7.24	27.17
1934	.99	9.34	33.34
1935	.73	9.12	28.66
1936	1.38	10.52	40.61
1937	.84	7.41	27.70
1938	.68	6.34	25.98
1939	.81	6.61	28.90
1940	.76	11.50	29.70

Source--United States Department of Agriculture, Agricultural Statistics, 1941, Soybeans Average Price, P. 302, Soybean Oil Prices, P. 401, Soybean Meal Prices, P. 402.

Working back from this table it is apparent that the price the farmers receive varies as the prices

(1) Grove, Ernest W., Soybeans in the United States; Recent Trends and Present Economic Status, U. S. D. A. Technical Bulletin 619, June, 1938, P. 17.

on meal and oil vary. In 1936 when the soybean price was highest, prices for oil and meal were highest. When oil and meal prices decreased, the price for seed decreased. This is not true for 1940. There is a seasonal variation that probably accounts for this. This is brought out by Mr. Grove in the following statement:

> "When the combined value of the oil and meal in a bushel is computed by months on the basis of monthly average prices of meal and oil, it can be seen that the price of soybeans fluctuates in much the same way but in lower levels. . . .
>
> "The correlation between the oil-and-meal value and the price of soybeans is by no means perfect, largely because of the seasonal demand for seed. Because of this factor, there is a marked seasonal variation in the spread between price and value." (1)

Meal prices are determined by price schedules on linseed meal, cottonseed meal, tankage and other high protein feeds. Oil prices are governed by prices of competitive fats and oils. In an editorial in the Soybean Digest, October, 1941, this statement is made:

> "We still maintain that usage of essential fats and oils is determined by cold business figures and not sentimentality. The different factors within the edible fats

(1) Grove, Ernest W., Soybeans in the United States; Recent Trends and Present Economic Status, U. S. D. A. Technical Bulletin 619, June, 1938, P. 17.

> "and oils field must maintain a balance.
> Prices will see that they do so." (1)

The author of this article goes on to quote figures to show that when soybean oil was relatively cheap in 1940, margarine manufacturers used 5,496,955 pounds of it as compared to 8,275,278 pounds of cottonseed oil. In 1941, when soybean oil was relatively higher, usage of soybean oil decreased 1,495,080 pounds and cottonseed oil increased 1,855,601 pounds. In the field of drying oils, soybeans compete with linseed, and with cottonseed in the edible oil field. As more oil enters the edible oil field, cottonseed has more influence on prices than linseed.

State Price Comparisons

It is interesting to note that over the past several years prices vary rather consistently by states. In order to show this, the comparative prices by states for 1939 and 1940 are included here. The leading producing states--the North Central states--tend to run average prices for the United States as a whole. The prices in the south tend to run higher than the average.

(1) Soybean Digest, The, Price Is King to Oil Buyers, Vol. 1, October, 1941, P. 1.

Table 11

Soybean Prices by States for 1939-1940
Price Per Bushel

State	1939	1940
New York	$1.19	$ .95
New Jersey	1.13	1.05
Pennsylvania	1.07	1.00
Ohio	.82	.80
Indiana	.81	.80
Illinois	.77	.70
Michigan	.90	.90
Wisconsin	.95	.85
Minnesota	.88	.75
Iowa	.81	.70
Missouri	1.00	.90
Kansas	1.05	.90
Delaware	.91	.85
Maryland	1.00	.95
Virginia	.99	.85
W. Virginia	1.34	1.25
North Carolina	.94	.85
South Carolina	1.81	1.50
Georgia	2.17	2.00
Kentucky	.97	.90
Tennessee	1.26	1.15
Alabama	2.43	2.00
Mississippi	1.46	1.30
Arkansas	1.15	1.10
Louisiana	1.18	1.20
Oklahoma	1.58	1.35
Texas	1.69	1.65
United States	.81	.76

Source--United States Department of Agriculture, Agricultural Statistics, 1941, Table 394, P. 300.

Comparisons with other Crops

The cost of production is affected by the growing and harvesting methods used, and the yield of beans or hay. Costs vary from farm to farm even where conditions are similar. There seems to be no available figures for average costs per acre on a national basis, but in Illinois, the largest grower of soybeans in the country, soybeans are rated next to corn in acre profit. Corn gave a net return of $10.52 per acre as a five-year average from 1935-1939, while soybeans returned an average profit of $5.85 over the same period. In this study conducted in Illinois, it was determined that the average cost of producing a bushel of soybeans dropped from an average of $1.50 for the five years 1922-1926 to fifty-six cents for the years 1935-1939. It is believed that this decline in cost of production may be attributed to the use of the combine and increase in per acre yield. Relative value of the soybean crop as compared with other crops in east-central Illinois from 1935-1939 is given in the following table. The big loss for soybean hay is attributed to the high labor cost of harvesting, since a large part of soybean hay is put up only as a means of opening grain fields for the combine.

[illegible]

[illegible]

Table 12

Relative Profit Per Acre of Crops in East-Central Illinois, 1935-1939

Crop	Acre-Cost	Acre Yield Bu. or Ton	Price Per Bu. or Ton	Profit or Loss
Corn	$17.37	55	$ .51	$10.52
Soybeans	15.51	28	.76	5.85
Wheat	14.74	23	.78	3.15
Alfalfa	17.91	2.25	8.60	1.81
Oats	12.62	40	.26	-2.33
Clover Hay	12.35	1	8.00	-4.41
Soybean Hay	19.60	1.8	7.20	-6.28

Source--Soybean Digest, The, Soybeans Rate Next to Corn in Acre Profit, Vol. 2, January, 1941, P. 3.

The determination of what crops to grow is not necessarily determined by the per acre profit. This has been summarized very well by one author as follows,

> "The choice of what crops to grow and how many acres of each to plant will not always be governed entirely by the relative profitableness of individual crops but also by the most profitable combination of crops for the individual farm. A combination of several crops in a rotation will in the long run, prove most profitable if they are well selected to give good labor and power utilization and, at the same time, to maintain soil fertility." (1)

Futures in Soybeans

Soybeans were added to the Chicago Board of

(1) Soybean Digest, The, Soybeans Rate Next to Corn in Acre Profit, Vol. 2, January, 1941, P. 3.

Trade in October, 1936, thus achieving the same economic status as corn, wheat, oats, barley, and rye. Soybeans were the first crop to be added to this list in many years. Trading in futures was inaugurated to fulfill "the need for and desirability of a soybean market which would provide hedging facilities for farmers, elevators, and processors, thus providing them a means of reducing the risks of adverse price changes." (1)

Table 13
Chicago Soybean Futures

Total Volume of Trading in All Futures Combined, by Months, from January, 1937 to October, 1941
(In thousands of Bushels)

Month	1937	1938	1939	1940	1941
January	2,586	1,199	1,196	11,146	40,884
February	1,332	597	1,120	9,548	41,974
March	1,139	938	2,677	9,440	65,670
April	1,763	1,695	1,076	9,125	118,325
May	1,405	1,399	3,348	8,768	131,086
June	2,850	799	3,108	1,920	117,908
July	1,995	970	4,281	2,407	89,777
August	3,399	1,378	4,479	4,133	82,101
September	2,346	1,246	7,443	4,335	98,528
October	3,936	7,316	12,889	17,169	91,517
November	3,151	3,813	15,005	31,320	
December	1,416	2,128	23,321	25,660	
Total	27,318	23,478	79,943	134,971	

Source--Lesar, James C., The Bean: and the Pit, The Soybean Digest, Vol. 2, December, 1941, P. 6.

As this table indicates, trading tends to

(1) Lesar, James C., The Bean: and the Pit, The Soybean Digest, Vol. 2, December, 1941, P. 6.

increase just before harvest, which would suggest the processors are engaging in hedging. As an indication of the advantages that trading in futures in the Pit offers to soybean growers, Mr. Lesar's says,

> "The futures market possesses sufficient liquidity to assure the prompt execution of orders, and thus provides a continuous and elastic outlet for the soybean crop every business day of the year. In addition, the fact that there is ever present in the futures market a body of professional risk bearers makes it certain that the various factors influencing prices will be considered, and thus reflects in the price of the futures. It is also true that trading in soybean futures results in an almost continuous series of price quotations which are widely disseminated throughout the country, and which serve as a basis of establishing soybean prices over wide areas." (1)

In the latter part of November, 1941 the Commodity Exchange Administration issued a report with the thesis there should be greater Governmental control of future trading in soybeans. This control should, according to the CEA report, involve increased margin requirements, and restrictions on "excessive in-and-out" trading or scalping operations. The report stated:

> "Farmers were said to have constituted the largest occupational group participating in the market operations. The CEA said it was very rare for prices of any agricultural commodity to reach a level which attracted

(1) Lesar, James C., The Bean: and the Pit, The Soybean Digest, Vol. 2, December, 1941, P. 8.

> "farmers to enter future markets on the short side as was done in case of soybeans this season." (1)

It was also disclosed in this report that hedgers as a group were carrying their own risks instead of being carried by speculators. On December 15, 1941 trading in soybean oil futures was suspended on the New York Produce Exchange.

Trading in futures in soybeans is a comparatively new project on the Pit, and perhaps, through greater Governmental control, conditions will be improved for all concerned. The sharp variations in prices are not helpful to either farmers or processors.

Governmental Regulations As They Affect Prices

There have been a number of Governmental regulations which have affected production, and by increasing production, have tended to affect prices. In 1936 AAA restrictions on other grains tended to increase production. Again in 1941, a revision of the AAA program reclassified soybeans as a soil conserving, rather than a semi-depleting crop. Then, again, the Government has been purchasing not less 3,000,000 pounds of soybean flour a month since August, 1941 for shipment to Great

(1) New York Times, New Curbs Asked in Bean Futures, November 27, 1941, P. 35.

Britain. In order to assist in the orderly marketing of the 1941 crop, the Department of Agriculture announced a "soybean loan" program. Loans are made through the Commodity Credit Corporation at the rate of $1.05 per bushel for soybeans grading No. 2 or better stored on farms, and loans of seven cents less per bushel stored in warehouses. This arrangement is to enable farmers to hold their soybeans for marketing at a later time. It is also designed to prevent over-crowding storage facilities of crushing mills and commercial warehouses.

At the end of February, 1942, as a means of increasing production of domestic fats and oils, the Department of Agriculture put a platform under prices of soybeans. The Commodity Credit Corporation will support prices between $1.40 and $1.60 a bushel depending on the grade. In addition to this, they will loan on farm-stored soybeans at a rate five cents higher than the $1.40 to $1.60 price.

With the AAA decision to increase the production of soybeans, it is probable that governmental regulations will be more numerous both as to production and price control in the future.

CHANNELS OF DISTRIBUTION

World Trade

It has only been within the past few years that production of soybeans in the United States has compared favorably with production in other countries. The following table for the past four years will give the relationship of the United States to world production.

Table 14

World Production of Soybeans for Four Years 1937-1940.

Thousands of Bushels

Country	1937	1938	1939	1940
China	213,189	207,600	203,900	216,800
Manchukuo	159,907	157,445	144,952	140,617
U. S. A.	45,272	62,729	91,272	79,837
Hungary			125	194
Roumania	2,584	1,803	3,532	3,600
Yugoslavia	54	140	103	294
Bulgaria	419	246	613	1,451
Total World	466,000	473,000	477,500	483,500

Source--Economist, The, Soya Bean Supplies, Vol. 140, April 12, 1941, P. 500.

World production excludes Soviet Russia but includes Chosen, Japan, the Dutch East Indies, and a number of smaller producers. In terms of per cent, each country produced as follows:

Table 15

Per Cent of Total World Soybean Production from 1937-40

Country	1937	1938	1939	1940
China	45.7	43.9	42.7	44.8
Manchukuo	34.3	33.3	30.4	29.1
U. S. A.	9.7	13.3	19.1	16.5
Hungary			.02	.04
Roumania	.55	.38	.73	.74
Yugoslavia		.02	.02	.07
Bulgaria	.08	.05	.12	.30

Percentages on this table do not equal one hundred per cent as all countries are not given.

In this connection it may be of interest to note the world trade of each of the principal producing countries.

Table 16

Exports and Imports of Soybeans for Years 1938-1939.

	1938 Exports	1938 Imports	1939 Exports	1939 Imports
	1,000 bu.		1,000 bu.	
China	85	0	225	0
Manchukuo	79,545	0	62,897	0
United States	2,645	3	10,462	2

Source--United States Department of Agriculture, Agricultural Statistics, 1941, P. 305.

In terms of per cent of total production, each country exported as follows:

Table 17

Per Cent of Total Production Exported for Years 1938-1939.

	1938	1939
China	.04%	.10%
Manchukuo	55.00	45.00
United States	2.9	13.00

Thus it would seem that Manchuria is the chief exporter of soybeans, while the United States and China consume most of their product at home.

The principal importing countries of soybeans for 1938 and 1939 were:

Table 18

Countries Importing Soybeans, 1938 and 1939
1,000 bushels

Country	1938 Imports	1939 Imports
Germany	28,766	*
Japan	24,815	25,032
United Kingdom	3,679	1,313
Sweden	5,346	*
Italy	592	*
Netherlands	4,042	4,371
Canada	61	154

*Unavailable

Source--United States Department of Agriculture, Agricultural Statistics, 1941, P. 305.

Of these countries, Japan has been the only exporter of any quantities. Japan exported 26,000 bushels in 1938; 30,000 bushels in 1939.

The United States has not imported soybeans

nor soybean products to any large extent since the last war. At that time considerable quantities of oil were imported, as there was a shortage of vegetable oils and some of the European outlets were closed. Imports of meal and cake were steadily increasing up to 1930, when there was a levy of tariff duties. The effect of this tariff is brought out in the following statement, "Imports of meal and cake reached approximately 86,000 tons in 1929; in 1931 there were only 20,000 tons." (1) Imports reached a total of nearly three hundred thirty six million pounds in 1918. The emergency tariff of 1921 and increased tariff duties of 1930 caused declines in imports.

The United States has not exported oil to any large extent. It was expected that at the outbreak of the war, considerable quantities would be shipped to England. In 1939 the United States exported 12,111,000 pounds of oil. The exports of oil in 1938 were only 6,412,000 pounds. Exports for the 1939-40 season increased as is shown by the following statement:

> "United States exports of soybeans, soybean oil and soybean meal in the 39-40 market season ending with September were at record levels the Department of Agriculture

(1) Burlison, W. L., The Soybean--A Plant Immigrant Makes Good, Univ. of Ill., September, 1936, P. 7.

> "reported today. The large exports are attributed to the unusually large European demand and to the record 1939 domestic crop. Because of war conditions, however, the export of beans and meal in the current season is expected to be insignificant and that of soybean oil to be substantially below the last year's level. . . Export buying was particularly heavy in the summer and fall of 1939 due to the difficulty of most European countries in obtaining Manchurian beans." (1)

In 1940 the largest exports of oil were made to Cuba, Finland, and Switzerland.

Foreign trade business changes as the war picture shifts. Elimination of the Scandinavian countries as potential buyers will affect the exports from this country. The effect of the war on soybean exports is brought out in the New York Times in the statement,

> "The serious effects which the German invasion of the Netherlands and Belgium will have on American export trade and British food supply are emphasized in the Commerce Department report today, (May 19, 1940). American exports of soybeans will suffer." (2)

Manchuria has been the main exporter of soybeans, but this picture is changing constantly. In 1941, through a shortage of gunnysacks, it was expected that their exports would be diminished considerably. It is difficult to make bulk shipments unless an even

(1) New York Times, Soybean Exports Up, November 5, 1940, P. 41.
(2) New York Times, U. S. Commerce Reports on Exports to Scandinavian Countries, May 19, 1940, P. 9.

temperature can be maintained. In February, 1940 British agents tried to buy up export surpluses of soybeans in Manchuria to prevent the supplies from reaching Germany. "The British bought 100,000 sacks offered at Yingkow before German exporters in Manchukuo discovered their activities and out bid them on additional orders." (1)

In the summer of 1941 it was reported that the Manchurian and North China crops were being ruined by the Japanese. Japan established a monopoly control system in Manchuria and North China, and, according to foreign businessmen and travelers, it was completely bankrupting the two countries. One businessman reported,

> "At present Manchukuo's soybean crop is approximately half of what it has been in previous years and all indications point to further reductions. The reason for this serious curtailment in Manchukuo's most important product is that after the harvest the peasant farmer producer must sell his bean crop to a government controlled receiving agency. Afterward the farmer must buy necessaries for living and continue farming entirely through Government controlled selling agencies and again the prices announced by the agencies." (2)

Thus it would seem that world trade and the part that the United States will play in that world trade is unpredictable. With both exporting and importing

(1) New York Times, Britain Buys Manchukuo's Product, February 26, 1941, P. 23.
(2) New York Times, Japan Held Ruining North China Farms, June 21, 1941, P. 4.

countries being cut off from the source of supply, it would seem that the United States will need to produce what it needs to consume and will have to consume most of the domestic crop. Increased shipments will probably be made to Canada and England. The Canadian Government in November, 1940 issued an order permitting the free entry of soybean oil for use in canning fish.

Farm Distribution

Soybeans grown on farms are distributed in three channels. They are grazed or plowed under, they are harvested for hay, or they are sold as beans. The beans that are sold are either returned to farmers in the form of feed, seed, or they go into industrial uses. The distribution of the farm crop since 1924 is shown on the following table. The total acreage figure equals the total acres grown alone plus approximately one-half the interplanted acres.

Table 19

Soybeans Harvested for Hay, Harvested for Beans, Grazed or Hogged off, 1924-1940, 1000 acres.

Year	Harvested for Hay	Harvested for Beans	Grazed or Hogged off	Total
1924	1,147	448	187	1,782
1925	1,175	415	195	1,785
1926	1,431	466	230	2,127
1927	1,556	568	226	2,350
1928	1,609	579	251	2,439
1929	1,742	708	286	2,736
1930	2,021	1,008	358	3,387
1931	2,700	1,104	390	4,194
1932	2,675	977	397	4,049
1933	2,443	997	337	3,777
1934	4,069	1,539	386	5,994
1935	4,000	2,697	414	7,111
1936	3,251	2,132	1,263	6,646
1937	3,480	2,549	976	7,005
1938	3,788	3,105	1,303	8,196
1939	4,612	4,417	1,460	10,489
1940	4,883	4,961	1,618	11,462

Source--Grove, Ernest W., Soybeans in the United States; Recent Trends and Present Economic Status, June, 1938, P. 7., to 1937, 1938-1940 from Agricultural Statistics.

The percentage that has been harvested for beans for each of these years is given on the following page. This table indicates that there is a gradual increase in the percentage of the crop that is harvested for beans.

Table 20

Per Cent of Soybeans Harvested for Beans
1924-1940

Year	Percentage Harvested for Beans
1924	25.1%
1925	23.2
1926	21.9
1927	24.2
1928	23.7
1929	25.9
1930	29.8
1931	26.3
1932	24.1
1933	26.4
1934	25.7
1935	37.9
1936	32.1
1937	36.4
1938	37.9
1939	42.1
1940	43.3

Government reports on the 1941 crop state, "The Department of Agriculture estimates that sixty per cent of the country's soybean acreage will be harvested for beans." (1) Increased industrial uses has something to do with the increased percentages harvested for beans, but, at the same time, a big percentage of the soybean crop has to be consumed by agriculture. Since

(1) U. S. Department of Commerce, Industrial Reference Series, Foodstuffs, No. 74, Sept., 1941, P. 7.

1924 the beans have been disposed of in the following manner:

Table 21

United States Disposition of Soybeans
1,000 Bu.

Year	Production	Used for Seed Total	Used for Seed Home Grown	Fed to Livestock	Sold
1924	4,947	1,941	702	1,207	3,038
1925	4,875	2,336	783	1,174	2,918
1926	5,239	2,570	908	1,311	3,020
1927	6,938	2,721	996	1,631	4,311
1928	7,880	3,041	1,091	1,473	5,316
1929	9,398	3,811	1,541	1,717	6,140
1930	13,471	4,749	2,205	1,929	9,337
1931	16,733	4,583	2,259	1,975	12,499
1932	14,975	4,250	2,161	1,985	10,829
1933	13,147	7,551	3,067	2,108	7,972
1934	23,095	9,422	5,462	1,810	15,823
1935	44,375	8,170	4,623	3,537	36,215
1936	29,983	8,070	4,404	2,464	23,115
1937	45,272	10,281	5,312	3,393	36,567
1938	62,729	13,757	7,721	4,481	50,527
1939	91,272	16,068	9,400	5,577	76,295
1940	79,837	14,783	8,590	5,346	65,901

Source--United States Department of Agriculture, *Agricultural Statistics*, 1941, P. 393.

By deducting what the farmers actually purchased for seed from the total seed sold, it has been determined that the following amounts went in to industry and into some form of manufactured product:

Table 22

Soybeans Used in Industry
1924-1940

Year	1,000 Bu.
1924	1,799
1925	1,365
1926	1,358
1927	2,586
1928	3,366
1929	3,870
1930	6,793
1931	10,175
1932	8,740
1933	3,488
1934	11,863
1935	32,668
1936	19,449
1937	31,598
1938	44,491
1939	69,627
1940	59,708

In 1924 fifty-seven per cent of the beans harvested were sold for industrial purposes; in 1940 this had increased to approximately eighty-eight per cent.

USES OF SOYBEANS

Soybeans have been used as a main source of food in Oriental countries for centuries. It was used as a forage crop when it was first introduced to this country. Today its uses numoer in the hundreds, and new uses are being found daily. The people in this country have been slow in adopting the soybean for a food, but new plants are being built constantly to produce manufactured products. As it is often stated, everything from hay to hairpins can be made from soybeans. One author aptly sums it up by saying, "With the soybean, as with no other plant, can man feed, clothe and house himself and manufacture counteless further articles." (1) The chart given on the following page indicates the many uses for soybeans.

Agricultural Uses

The main outlet for soybeans is in feeding, either in the form of hay, silage, soybeans, or meal. In an experiment conducted at the Iowa Agricultural Experiment Station, the cost of feeding a supplement of soy oil meal to cattle was less than either linseed

(1) Time, Jack and the Soybean, September 15, 1941, Vol. 37, P. 41.

SOYBEAN UTILIZATION

- SOYBEAN
  - Plant
    - Forage, Green Manure, Pasture
      - Ensilage
      - Fuel
      - Furfural
      - Hay
      - Soilage
  - Bean
    - Meal
      - Celluloid substitutes
      - Core binder
      - Feeds
        - Cattle
        - Dogs
        - Fish
        - Hogs
        - Poultry
        - Rabbits
        - Sheep
      - Fertiliser
      - Glue
      - Human food
        - Beer brewing
        - Flour - see dried beans
        - Seasoning powders
        - Soy sauce
        - Vegetable milk
      - Plastics
      - Water paints
    - Oil
      - Candles
      - Celluloid
      - Core oil
      - Disinfectant
      - Electrical insulation
      - Enamels
      - Food products
        - Butter substitutes
        - Cooking oils
        - Lard substitutes
        - Salad oils
        - Medicinal oil
      - Fuel
      - Glycerin
      - Insecticides
      - Lecithin
        - Candies
        - Chocolate
        - Cocoa
        - Emulsifier
        - Margarine
        - Medicines
        - Textile dyeing
      - Lighting
      - Linoleum
      - Lubricant
      - Oilcloth
      - Paints
      - Printing ink
      - Rubber substitutes
      - Soaps
        - Hard
        - Liquid
        - Soft
      - Varnishes
      - Waterproof for cement
      - Waterproof goods
    - Green bean
      - Canned
      - Frosted
      - Green vegetable
      - Salad
    - Dried bean
      - Baked
      - Boiled
      - Breakfast foods
      - Feeds
        - Cattle
        - Hogs
        - Poultry
        - Sheep
      - Flour
        - Baked products
        - Breakfast foods
        - Candies
        - Chocolate
        - Diabetic foods
        - Health drinks
        - Ice cream cones
        - Ice cream powder
        - Infant foods
        - Macaroni products
        - Meat products - filler
      - Roasted
        - Candied
        - Coffee substitute
        - Salted
      - Soy sauce
      - Sprouts
      - Vegetable milk
        - Casein
          - Paints
          - Paper size
          - Textile dressing
          - Waterproofing
        - Condensed
        - Curd
          - Canned
          - Dried
          - Fermented
          - Fresh
          - Smoked
        - Foods
        - Powder

Compiled in the Division of Forage Crops, Bureau of Plant Industry, U.S.D.A.

or cottonseed supplement. Similar results were secured at the University of Illinois in the feeding of hogs:

> ". . . the University of Illinois has shown that $5\frac{1}{2}$ to 6 bushels of corn and fifty pounds of soybean oil meal will produce 100 pounds of pork. Compare this with straight corn feeding which generally requires 10 to 12 bushels to produce 100 pounds of pork. The cost of the corn-soybean oilmeal ration required to produce 100 pounds of pork is much less than the cost of the straight corn required to produce 100 pounds of pork." (1)

This study further discloses that the rate of gain is much faster on the corn-soybean oilmeal ration, and that costs would be diminished greatly if farm grains were supplemented with a protein food such as soybean oil meal.

There are advantages and disadvantages in the utilization of soybean products for animal feeding. These are discussed here in summary form for each type of animal.

Dairy Cattle

Experiments at the University of Illinois show that soybeans may be used to an advantage in the feeding of dairy cattle. This is brought out in the following summary:

(1) Maltas, K. J., Hogs Can't Perform Miracles, The Soybean Digest, August, 1941, Vol. 2, P. 16.

> "Used in the grain mixture, soybeans have greatly improved dairy rations and increased money returns from the herd. . . Thus many dairymen who lack the capital or inclination to purchase high-priced protein supplements find a solution to their problem when they grow their soybeans. The growing of this crop, together with alfalfa, red clover and sweet clover, assures them an adequate supply of protein whenever prices of commercial protein supplements become too high." (1)

The feeding of soybeans to dairy cattle may take several forms--it may be in the form of silage, hay, straw, meal, or beans. As a general rule, it is more satisfactory to feed the ground meal to cows than the seed. Sometimes soybeans and corn are grown together for silage; sometimes soybeans are grown alone. Experiments at the University of Illinois have shown that when the two are grown together the yield of total nutrients is not appreciably affected, as the corn yield reduction equals or exceeds the yield of beans. If the beans are saved in the harvesting of the crop, the yield of protein may be greater when the two are combined. It is easier to combine soybean with corn for silage than other legumes as the harvesting time is practically the same.

The value secured from the feeding of soybean

(1) Nevens, W. B., Making Use of Soybeans in Feeding Dairy Cattle, Utilizing the Soybean Crop in Livestock Feeding, Univ. of Ill., June, 1937, P. 7.

hay is affected by the way the crop is harvested and planted. It is possible to feed too much soybean hay to dairy cattle. Dairy cows refuse the coarser parts of the hay, but experiments have shown that the portions refused have very little protein value.

If moldy hay is fed to dairy cattle, undesirable flavors in milk and cream are produced. This is also true if ground soybeans form over twenty-five per cent of the grain mixture.

Soybeans for Beef-Cattle

If grown alone, soybeans do not make as satisfactory pasture for beef cattle as do red clover, alfalfa, or sweet clover. Soybeans planted with other crops as sudan grass, however, offer possibilities as a pasture crop. Experiments at Purdue University show that for fattening cattle, soybean hay is slightly superior to clover hay as roughage. In the Purdue experiment a lot of ten two-year old steers was fed a ration of shelled corn, cottonseed meal, corn silage, and clover hay; another lot was fed a similar ration except that soybean hay was substituted for clover hay. The results of the test were reported as:

> "The lot that received clover hay made an average daily gain of 2.41 pounds per head during the 140-day feeding period, the

> "soybean lot gained 2.59 pounds. . . The feed cost per hundredweight gain, however, was markedly in favor of the soybean-hay lot even when soybean hay and clover hay were charged at the same price." (1)

Experiments at the Ohio Station showed the same results--that cattle fed soybean hay made slightly more rapid gains than those fed clover hay and the feed cost of gains was slightly lower for the soybean-hay lot. Soybean straw can be fed to an advantage to beef cattle. An interesting experiment was performed at the Tennessee Station to determine the value of feeding on a per acre basis. Three lots of four steers were fed from an acre of corn, soybeans, and cowpeas. Each lot received in addition to this a base ration of twenty pounds of corn silage per head daily. The crops were planted and harvested in the ordinary way. The corn was harvested and cured in the field; the ears were made into corn-and-cob meal and the stalks cut in a silage cutter. The soybeans and cowpeas were also cured in the field and the beans and peas threshed out and ground into a coarse meal. The results of these tests showed:

> "In the first year's trial the acre of soybeans proved superior to the acre of cowpeas or corn as a supplement to the basal ration of 20 pounds of corn silage daily.

(1) Rusk, H. P., Soybeans for Beef-Cattle Feeding, Utilizing the Soybean Crop in Livestock Feeding, Univ. of Ill., June, 1937, P. 12.

> "This result was so unexpected that a second trial was made, but the second trial only confirmed that of the first year in demonstrating the superiority of the soybean." (1)

The average daily gains on each test were:

First Test	Average Daily Gain
Soybeans	1.27
Cowpeas	1.21
Corn	.59

Second Test	Average Daily Gain
Soybeans	1.68
Cowpeas	1.51
Corn	.94

The same station conducted experiments to determine the amounts of beef that the crops from an acre of land would produce. Considering the returns over a series of years, alfalfa hay and the combination of soybeans and barley were outstanding. Results have been conflicting in experiments in feeding soybean oil meal to cattle at Purdue and Illinois. The general conclusions are however, that soybean meal gives fully as good results as cottonseed, and that the whole beans are superior to ground beans. The advantages of feeding soybeans to cattle is summarized by Mr. Rusk in the following statement:

> "No other feed crop commonly grown on corn-belt farms produces grain so high in protein as does the soybean. . . Investigations

(1) Rusk, H. P., Soybeans for Beef-Cattle Feeding, Utilizing the Soybean Crop in Livestock Feeding, Univ. of Ill., June, 1937, P. 17.

"at the University of Illinois have shown that soybean protein has a high biological value as compared with many of the other vegetable proteins." (1)

Soybeans for Sheep

In summarizing the value of soybeans for sheep, it may be said that the hay is of practically the same value as clover for lambs; soybean straw has very little value; and that both beans and oil meal are good supplementary food. Feeding experiments at Illinois and Purdue have shown that there is little difference in the value of whole beans as compared with ground beans for sheep, or of soybean oil meal as compared with cottonseed or linseed meals.

Soybeans for Horses and Mules

As a feed for horses and mules, soybeans have been used mostly as roughage. Its use is stated by one author as:

"Rations of soybean hay and corn, or soybean hay, corn and oats have been reported by many Illinois farmers as very satisfactory for work animals. . . Soybean has proved an excellent roughage for fattening mules." (2)

(1) Rusk, H. P., Soybeans for Beef-Cattle Feeding, Utilizing the Soybean Crop in Livestock Feeding, Univ. of Ill., June, 1937, P. 17.
(2) Edmonds, J. L., Crawford, C. W., Soybeans for Horses and Mules, Utilizing the Soybean Crop in Live-Stock Feeding, Univ. of Ill., June, 1937, P. 27.

Soybean straw is a better feed than other forms of straw, but there is more waste. Very little use has been made of beans for horses and mules.

Soybeans for Swine

Soybeans have limited value in swine feeding, particularly for swine that is being raised for the market. They do not excel as a pasture crop. Beans in the bean form are unpalatable to pigs, but cooking seems to remedy this situation to some extent. The main objection to feeding soybeans to pigs is that it produces soft pork, believed to be due to the oil in the food. If pigs are fed meal from which the oil has been removed, there are no detrimental effects on the pork. It makes an excellent protein supplement.

Soybeans for Poultry

Experiments conducted by Mr. Sloan of the University of Illinois on feeding soybeans to poultry showed:

> "For growth and egg production, soybean oil meal supplemented with sufficient minerals of the right kind appears about equal to meat scrap and fish meal, somewhat better than tankage, gluten feed, and cottonseed meal, and not quite as good as dry milk products." (1)

(1) Sloan, H. J., Soybeans for Poultry, Utilizing the Soybean Crop in Livestock Feeding, Univ. of Ill., June, 1937, P. 43.

Soybean meal is more satisfactory to use than ground soybeans. Freshly cut soybean hay can be used as a green feed to supplement poultry rations. Soybean hay, well cured, may be used in winter when other green feeds are apt to be scarce.

Industrial Uses for Soybean Meal

When beans are taken to the processors, the oil is extracted and the meal is left. Generally speaking, one ton of beans yields four hundred pounds of oil and sixteen hundred pounds of meal; in other words, eighty per cent of the beans are made into meal. One bushel produces one gallon of oil and forty-eight pounds of meal. The number of businesses engaged in the manufacture of soybean oil, cake, and meal increased from twenty-six in 1937 to forty-seven in 1939. At present some ninety soybean mills and a number of cottonseed mills are crushing soybeans for oil and oil meal, fifty concerns are manufacturing soybean food products, fifteen mills are making soybean flour, and more than fifty factories are turning out various industrial products. It is estimated that approximately seventy-eight per cent of the crushed bean is turned into meal for animal feed. As the value and importance has been discussed previously, it will not be taken up here, but its value as animal

feed must not be minimized.

Soybean Flour

There are several industrial outlets for the meal, and one promising outlet we shall hear more about as time goes on is soybean flour. The United States is sending to Great Britain three to four million pounds of soybean flour every month. Although experiments have been made since 1917 in developing soybean flour, it has not been until recent years that it has appeared on the market. It was accepted in Canada before much was done with it in this country. Soybean bread was first sold in California and was so well liked there, it has been introduced in other markets.

Soybean flour is made by grinding either the whole bean, the pressed cake, or the cracked or flaked bean from which most of the oil has been removed. There have been two difficulties to overcome in the manufacture of soybean flour--first, the elimination of the bitter and beany flavors, and second, the stabilization of the finished product against deterioration. It is believed that the flour produced today has eliminated both of these objections.

The amount of proteins, minerals, vitamins, and energy units contained in soybeans makes them one

of the cheapest sources of foods available to man. It is also an excellent source of Vitamin B, a fair source of Vitamin G, and contains some Vitamin A. The amount of calcium is twenty times greater than that in potatoes, twelve times that found in eggs, and about two times the amount in milk. Flour processed by the solvent method contains the most protein, as high as fifty-four per cent. Most of the twenty amino acids which constitute proteins are found in soybean flour.

Soybean flour has had two boosts within the past year; one, the increased shipments to England, and the second the acceptance of the flour by the Army. Three manufacturers have been working on it, Loose-Wiles, National Biscuit, and Miller-Parrott. The content of the flour as accepted by the Army is summarized in the following statement:

> "A baker batch of the approved pemmican contains 103 pounds of wheat flour, 73 pounds of whole wheat flour, 100 pounds low fat soya flour, 112 pounds whole egg, 114 pounds shortening, 70 pounds fine cut oatmeal, 32 pounds gelatin, 70 pounds dried skim milk, 24 pounds sugar, 12 pounds molasses, 3 pounds ammonium bicarbonate, 3 3/4 pounds salt and 9 ounces cinnamon." (1)

At the time the Army accepted the flour for bread, they rejected the ten per cent "soya" from the chocolate

(1) Business Week, <u>A Point for Soya</u>, November 1, 1941, P. 32.

malted milk tablets. However, the Army is looking for other uses for soybeans. Experiments are being conducted with dehydrated vegetable soup containing "dehulled, debittered" soybeans. Soybean grits to be used as cereal to be eaten with milk or to be made into water gruel are being tried. In view of the fact that soybeans could be easily shipped, it is believed feasible to utilize them as much as possible in foods.

The German Army as well as the American Army has recognized the food value of soybeans in developing what they call "full soya"--a form of flour. Its high nutritive value may be shown by the following comparisons:

Table 23

Comparative Table to Show Nutritive Value of Soya Flour

Calory Count

Every 1,000 grams contain:

	Protein Grams	Fat Grams	Calories Number
Wheat flour	116	16	3590
Rye flour	100	11	3530
Pea flour	257	18	3570
PURE SOYA	615	202	4660
Lean beef	206	35	1200
Fat pork	151	350	3890
Whole milk	34	36	670
Eggs (20 units)	112	106	1480

Source--Soybean Digest, The, German Army Soya Cook Book, a Translation, Vol. 2, December, 1941, P. 3.

This "pure soya" flour is not intended to replace wheat flour. In the case of baked or boiled foods made with the flour, "pure soya" can take the place of only a comparatively small proportion of wheat flour. This flour has been developed particularly for use in the German Army, and suggestions are made for its use in the following cases:

1. It should be used as a means of making meat go further. In using minced meats, "pure soya" may be used to replace about twenty-five per cent of the meat.

2. "Pure soya" may be used as a means of economizing on fats. By using the flour in thickened soups and gravies, and vegetable dishes, it saves fat, since fat is an integral part of the flour. This may save from ten to forty per cent of the fat in these dishes.

3. It may be used as an egg substitute in cases where eggs are used as a binder to hold together dishes made with potatoes and flour dough.

4. Mixed with water in the proportion of one to ten "pure soya" may be used as a substitute for whole milk.

5. It may be used as a spread for bread.

The many possibilities for use by the Army

combined with the low cost have made it very acceptable. A pound of flour may be purchased for the price of five ounces of meat, but that pound is equal to two pounds of meat in nutritive value.

For home use soybean flour may be used to the extent of from ten per cent to twenty-five per cent of the total quantity of flour used. A twenty per cent mixture contains forty per cent more protein and one hundred fifty per cent more of the salt-free minerals than are found in white breads. The decrease in carbohydrates is approximately seventeen per cent. For people in lower income groups, the addition of soybean flour would guarantee the minimum requisites of calcium. In articles where flavoring extracts, chocolate, sugar, spices, or dried fruits are used the bean can be increased to fifty per cent. When unprocessed soybean flour is used in baked goods, the amount of shortening should be reduced some because of the high oil content. Some of the processed flours on the market have had part of the oil removed and some of the vitamins destroyed. Soybean flour is fifty per cent protein, thirty-two per cent carbohydrate, three per cent phosphatides, one per cent fat, six per cent ash, and eight per cent moisture.

The flour is used commercially as a filler up to thirty per cent in sausage, twenty-five per cent in

ice cream, cocoa, and chocolate, fifty per cent in soups, and limited amounts in candies and preserves. It is also used to increase the body of beer. Researchers at the Wisconsin Experiment Station have recently developed "bee bread". The bread is made from one part pollen and three parts soybean flour. It is used for winter sustenance of honey bees.

First National Stores in some sections have adopted the policy of selling "soybean bread" one day a week. It has been so successful where it has been tried, it is being introduced in other sections.

It is estimated by the Department of Agriculture that nearly one hundred billion pounds of bread are baked annually by commercial bakers. An even larger amount is baked each year by housewives, railroad, and steamboat companies. Over five hundred million pounds of macaroni are manufactured each year. The biscuit and cracker manufacturers use five million barrels of flour; self-rising and pancake flour consume another five million pounds. Ten million barrels are used in the manufacture of sweet goods. For most all of these products, twenty per cent soybean flour could be used to an advantage. The total potential consumption, based on present population, is over fifteen million barrels. Limiting factor is that it has not been put on the market in many localities.

Soybean flour and wheat flour are allies, not competitors. The use of the two together will benefit the consumer, the baker, the miller, and the farmer. Soybean flour will undoubtedly be used in larger quantities in the future. This is brought out by one author in the statement:

> "It is only a question of time until there will be a large usage of soy flour and grits in this country compared to the present business which is relatively small. . . The fine evidence of recognition of the high merit and quality of soy flour is the result of a great deal of effort, time, and work, and can only accompany products made in modern up-to-date plants by carefully controlled processes." (1)

Soybean Protein

Although work was started at the University of Illinois four years ago on soybean protein, its importance was not realized until this year. If it is possible to produce enough to take the place of milk casein, it will allow more milk for cheese, one of the most important needs of the food export program. It is believed by chemists in the field that twenty million pounds of soybean protein will be needed annually to augment the shortages in casein supplies resulting from

(1) Soybean Digest, The, Sees Wider Use of Soy Flour, August, 1941, Vol. 2, P. 15.

the national defense program. Over a million and a quarter bushels of soybeans will be required to fulfill the estimated needs. At the present time only one company is producing the protein in any quantity, and its capacity is only six million pounds annually. Two other companies have plans for building factories under serious consideration, one of which has already built a pilot plant. The treatment to produce the protein as given by one authority is:

> "Organic salts in the soybean meal make the protein easily available through a process of water and alkaline dispersion and subsequent precipitation. A pure, almost white protein is obtained by this process." (1)

The paper coating industry has consumed approximately three-fourths of the annual production of casein. Soybean protein produces a darker color in the paper coating than casein, and possesses some properties superior to those of casein. Large quantities are also used in the manufacture of plywoods, plastics, water paints, paper sizings, leather finishes and insecticide sprays. Soybean protein is considered an equivalent to casein in all of these uses.

The use of soybean protein in sizing has developed new possibilities in paper and paper manufac-

(1) Soybean Digest, The, <u>Soybean Protein Can Replace Casein</u>, August, 1941, Vol. 2, P. 15.

ture and permits the use of certain types of pulp which could not be used before for the manufacture of paper that was to be sized. It is expected that the use of adhesives in the plywood industry will consume large quantities of the protein in the future, since plywood construction has increased so rapidly. It is used exclusively for Pacific Coast fir and pine plywood. It is of particular value to furniture manufacturers in the preparation of veneer work, and by airplane manufacturers in the making of plane propellers. The glue prepared from this protein is water proof and has very great tensile strength. In manufacturing vegetable proteins there is a fine residue which is sold to manufacturers of dog foods and rabbit foods. The coarser material that is left is sold to plastic manufacturers to take the place of wood flour.

So far the price has been maintained around twelve cents a pound, as compared with a price fluctuation of seven to thirty cents a pound of milk casein. As processing methods improve, this cost may be reduced.

Soybean Fiber

Soybean fiber was first developed by two Japanese scientists--a result of their experiments on animal protein. Work has been done at the University of

Illinois and at the Ford Motor Plant, where twenty-five chemists have been at work on it. Just before the end of 1941, Ford Motor Company announced that the material was being produced at the rate of one thousand pounds per day in a pilot plant at Highland Park, Michigan, and that a new plant would soon open at Dearborn.

The difficulty in producing uniform protein necessitates control of the variety of the soybean and chemical analysis and fertilization of the soil on which they are grown. The steps in producing fiber from soybeans as summarized by Mr. Boyer of the Ford Motor Company are:

1. The removal of oil from the meal. The continuous solvent extraction method is used to extract the oil. The crushed beans are washed counter currently with hexane. Then the meal, which has the oil removed, is passed through a steam jacketed pipe for removal of the solvent. The meal for fiber work must be treated at a lower temperature than meal.

2. The second step is the extraction of protein from the meal. There are several methods, but the one used by the Ford Motor Company is to treat the meal with a weak alkaline solvent for a half hour.

> "The resulting solution is clarified either by filtering or centrifuging the protein in the solution. The solution is precipitated with

"acid. The resulting curd is soft and dried." (1) As the protein may be discolored by iron, this must be done in stainless steel or glass lined equipment.

3. Age the protein at the right temperature for a right time to secure the correct stringiness.

4. The solution is forced through spinnerettes into an acid bath, and the filaments are collected on a reel or bobbin. The bath consists of sulfuric acid, formaldehyde, and salt.

5. The fiber is treated and dried, and then emersed in a formaldehyde bath.

The resulting fiber is white to light tan in color with medium luster. It has a warm, soft feel, and a natural crimp. It has a tensile strength of eighty per cent. It does not wet so readily as casein fiber and wool. It can be produced either in natural color or spun dyed. It may be used with cotton, spun rayon, or wool. It is purported to be "moth proof". There is a possibility it may be used with wool in felt manufacture. It may resemble wool or silk.

The wool was developed at the Ford Plant originally to be used for upholstery in cars, but it has

(1) Boyer, R. A., Soybean Protein Fibers, Industrial and Engineering Chemistry, Vol. 32, December, 1940, P. 1550.

many other possibilities. (1)

The fiber may be produced at a low cost. One author says,

> "Two acres of land devoted to sheep grazing will produce eight to ten pounds of wool per year. Two acres of land in soybeans will produce four hundred pounds of protein suitable for fiber." (2)

Soybean oil, which is of increasing value, is recovered in the first step of the fiber production.

Soybean Plastic

Soybean plastic was first invented by a Japanese scientist named Sato, who called his material "satolite". As early as 1915 in this country, a United States patent was issued for making plastic material from soybean meal. This was followed in 1917 and 1918 by a whole series of patents issued to Satow. The terms on these patents have expired, and the field is open to manufacturers.

In making the plastic soybean meal is treated with formaldehyde; a phenolic resin is added to the hardened meal, making a quick setting plastic. In the

(1) It is said that Henry Ford wears a "soybean fiber" suit containing twenty-five per cent protein fiber.
(2) Science News Letter, Soybean Fiber, Volume 39, March 10, 1941, P. 148.

molding, equal parts of the hardened meal, woodflour, and resin are used. Soybean meal produces a plastic which is light, almost transparent, waterproof, fireproof, and rotproof. The main drawback of the plastic is that it absorbs water too readily--about three per cent in forty-eight hours submersion.

In recent years the Ford Motor Company has developed the plastic to the place where it can be used for entire bodies of cars. (1) Before it was developed to this point, trial experiments were conducted on car trunks and tractor seats. Mass production on car bodies was to go into effect before the work was transferred to defense effort. Other manufacturers have developed many minor items, as automobile parts and accessories, such as distributors, coil cases, accelerator pedals, trays for refrigerators, drinking cups, and ash trays.

There is a liquid form of the plastic that may be used in textiles, paper, and leather industries. One large tanner is using it to produce a grade of men's shoe, the same weight as calfskin. Several paper mills are using it as a water-resistant sizing. Four to five thousand tons a year are used in the production of buttons, in competition with natural horn, bone, and

(1) See Page 18.

paper plastics.

One of the newest plastic products is a helmet made out of heavy cotton cloth and soybean, developed by the Soybean Products Laboratory of the Department of Agriculture and the cotton specialists of the Southern Regional Research Laboratory. The helmet is used to protect the heads of miners and workers on construction jobs from falling material. They are reported to be strong enough to deflect a blow of forty pounds, and are much lighter than the old style of metal helmet.

With the reduced production of automobiles, it is questionable how much plastic can be absorbed by industry.

Soybean Egg Whites

Synthetic soybean egg whites is a pale yellow powder which turns white when mixed with five parts of water. This synthetic egg white was discovered by Mrs. Doris Ulrich Grundy, a graduate student in Home Economics at the University of California, in the spring of 1940. It may be used in standard recipes for hard meringues, candies and frozen desserts. The substance will foam to fourteen times its volume, and is tasteless in cooking. In eliminating the bitter taste, all the fats are extracted from the flour by mixing it with

petroleum ether and filtering, then adding hydrochloric acid. This bitter material is glycinin which can be used in plastics, and is particularly valuable in the manufacture of glue.

Rubber Substitute

Scientists in the Department of Agriculture hope to develop a process to transform soybean meal into a substitute for rubber. The process, which for military reasons cannot be described in detail, consists of a series of chemical changes which transform the protein molecules of soybean meal into molecules similar in structure to those of rubber. Its possibilities are summarized in the following:

> "Soybean rubber, according to chemists of the bureau, won't come the day after tomorrow, but it is on the way. It's possible on paper." (1)

Industrial Uses for Soybean Oil

Soybeans were first crushed for oil in this country in 1910 by a mill on the Pacific Coast. These beans were imported from Manchuria. After that time beans were imported yearly for crushing. The first

(1) Science, Supplement, Soybean Rubber, Vol. 95, January 9, 1942, P. 10.

record of American grown soybeans being crushed is in 1915 by a few cottonseed mills in North Carolina. A shortage of cottonseed and a surplus of soybeans at that time led to rather an extensive use of domestic seed for that purpose. The industry spread to the south during the World War. At that time a large quantity of oil was imported to replace the oils and fats exported to Europe. Consumption of soybean oil fell off after the war and remained relatively small until 1929 when larger supplies became available as a result of increasing domestic production of soybeans for crushing. The paint and other drying oil industries took most of the oil between 1931 and 1934. The proportion used in the drying oil field increased steadily to sixty-four per cent of the total in 1934, with only fifteen per cent going into edible products in that year. In 1936, because of the reduced supplies of lard and cottonseed oil, the demand for soybean oil for edible purposes expanded. The distribution of soybean oil according to classes of products, as given by the United States Census Bureau since 1936 is shown on the following page.

Table 24
Factory Production and Consumption of Soybean Oil in the United States

1,000 Pounds

	1936	1937	1938	1939	1940
Total Factory Production	225,297	194,411	243,613	369,760	431,641
Shortening	113,897	90,798	143,318	201,559	212,317
Oleomargarine	14,262	31,793	39,885	70,882	87,106
Other Edible Products	21,598	15,530	11,280	32,345	39,980
Soap	5,023	10,274	10,897	11,177	17,612
Dry. Oil Ind.	17,419	17,157	18,847	28,220	36,620
Miscellaneous	3,405	3,038	5,340	9,332	16,538

Source--Soybean Digest, The, Soybean Oil--Who Uses It, Vol. 1, December, 1940, P. 3.

The consumption, divided as to food industries and non-food industries has been:

Table 25
Consumption of Soybean Oil by Food Products and Non-Food Products

Year	Total Consumption 1,000 lb.	Food Industries	Percent	Non-Food Industries 1,000 lb.	Percent
1936	175,604	145,757	85.3%	25,847	14.7%
1937	168,590	138,121	81.9	30,469	18.1
1938	229,567	194,483	84.7	35,084	15.3
1939	353,515	304,786	86.2	48,729	13.8
1940	410,173	339,403	82.7	70,770	17.3

The percentage going into food products in 1940 decreased slightly over that in 1939. In 1941, due to inability to get other vegetable oils, this may

be expected to increase.

The consumption of soybean oil has steadily increased, but cottonseed oil is still a leader in the edible oil field. In 1936, when soybeans had first started to be used extensively in food products, the percentage used was only 6.5, while cottonseed was used to the extent of 52.5 per cent. In 1940 soybean oil was the fourth most important oil used industrially in the United States, ranking behind cottonseed oil, inedible tallow, and coconut oil. Total factory consumption of major fats and oils in 1940 was:

	1,000 lbs.
Cottonseed oil	1,279,960
Tallow, inedible	885,685
Coconut oil	528,203
Soybean oil	431,641
Linseed oil	386,225
Grease	356,513
Fish oils	179,515
Palm oil	157,213
Eight leading fats and oils	4,204,955
Total, all fats and oils	4,737,585

Source--Soybean Digest, The, Soybean Oil Is Most Versatile of All, 1940 Factory Consumption Figures Show, Vol. 1, April, 1941, P. 13.

Although soybean oil is not the most important oil in any single product, it is one of the most versatile oils. It is surpassed by cottonseed oil in the edible fields, and by linseed oil in paints and varnishes.

Methods of Extraction

There are three general methods used in extracting soybean oil--the expeller, hydraulic, and solvent. In 1939 three-fourths of the oil was extracted by the expeller method, one-fifth by the solvent, and the remaining five per cent by the hydraulic method. The solvent method is gaining ground rapidly while decreasing quantities are being extracted by the hydraulic method. The solvent method leaves less oil in the meal than the other two methods, usually from one to five per cent. The expeller and hydraulic press methods leave from four to six per cent.

The expeller method is the one that has been used in Manchuria for centuries. When this method is used the soybeans are cracked, and a rotary drier cuts the moisture to two or three per cent. They are held at a temperature between 212 and 240 degrees Fahrenheit for ten to fifteen minutes. The soybeans are dropped into an expeller where the oil is expelled by pressure by a revolving shaft in a horizontal steel barrel. In about two to two and one-half minutes three-fourths of the oil is extracted. The expeller operates on the principle of a household meat grinder. The working pressure is about six tons to the square inch. The oil

is pumped through a rotary strainer on its way to storage, while the cake emerges in thin sheets that are broken up on a revolving cake breaker at the discharge end.

If the hydraulic method is used, the beans are prepared in practically the same way they are for the expeller method, except they are heated to a higher temperature before being pressed. When the meats are cooked they are taken out and formed into cakes. They are placed into hydraulic presses and left there fifty to sixty minutes, during which time the oil is released from the meats. The objection to this method is that it is not continuous and requires hand labor for loading and unloading the presses. It is used more for flaxseed and cottonseed than it is for soybeans.

When the solvent extraction process is used, the beans, instead of being granulated are rolled into thin flakes. This flaking operation is generally preceded by cracking and heating, and, occasionally, by addition of moisture. An explanation of the solvent extraction method is given by Mr. Goss of the United States Regional Soybean Industrial Products Laboratory in the following statement:

> "The extraction is accomplished by means of hexane or similar solvent which is sprayed

> "over the top basket on either side, percolating through lower baskets in succession. Freshly distilled solvent runs in countercurrent flow down through the ascending chain of baskets and the resulting solution, known as half-miscella, is collected and pumped to the top of the down-coming side so that it washes the descending baskets in parallel flow." (1)

The final solution of twenty to twenty-five per cent oil in solvent is filtered, and the solvent is evaporated. The final operation in the preparation of crude oil is to remove traces of solvent by means of a stripping column.

There is only one extraction plant in the world processing soybeans on any commercial scale using any solvent other than petroleum fraction. The exception is a Manchurian plant using ethyl alcohol. At present there are five solvent systems used in large scale soybean extraction in this country, two of German origin, and three of American origin. Solvent-extracted soybean oil is better for most industrial products, with the exception of adhesives. The meal that is left is better for plastics and other industrial products, but is not as good for cattle feed.

A new process which has not been developed on

(1) Goss, W. H., <u>Technological Problems in Processing Soybeans</u>, The Soybean Digest, Vol. 2, July, 1941, Pp. 2-3.

a commercial scale, but one which shows great promise is the fractional distillation method, or as it is also called, the liquid-liquid process. The object of this method is to separate the drying and non-drying portions of soybean oil. The process that takes place is given by one author as,

> "In this process the soybean oil is hydrolyzed or broken down to its component fatty acids and glycerine, then after removing the glycerine, the mixture of non-drying and drying fatty acids are passed through a specially designed distillation column where the fatty acids are vaporized and separated into purified fractions according to their boiling points." (1)

The drying fatty acids that are obtained are used in the production of synthetic resins. Automobile finishes, refrigerator coatings, varnishes, enamels, and printing inks all employ this synthetic resin. The drying fatty acids may be reconverted into a drying oil by chemically adding glycerine. This oil may be used in paints, oleo-resinous varnishes, core oil, linoleum, and other uses where it is necessary to have a drying oil. The non-drying fatty acids also have uses. They may be used in the compounding of synthetic rubbers and in the manufacture of soaps. Two new household soaps using

(1) Stingley, Dale V., Fractional Distillation Widens Soybean Oil Market, The Soybean Digest, Vol. 2, May, 1941, P. 2.

this product are now on the market. The non-drying acids of soybean oil may also be used in the field of lubrication.

The by-products of fractional distillation of soybean oil fatty acids are of importance. Glycerine and stearine pitch are recovered. Glycerine has many uses in industry. It is used in tobacco, explosives, adhesives, synthetic resins, paper, textiles, printing, cosmetics, and pharmaceuticals. There is an increasing demand for stearine pitch to be used as an ingredient in weatherproof electrical insulation, plastic molding compounds, mastic flooring, coated corrugated sheeting, paints, and enamels. Both in theory and in practice the fractional distillation method opens up a broad new chemical field.

Soybean Paint

Soybean oil is classified as a semi-drying oil, and so can ordinarily be used in paints and varnishes only when combined with some other oil of higher drying qualities as linseed, perilla, and tung oil. It is expected that with new processing methods, soybean oil can be made more of a drying oil and will not need to be used in combination with other oils. This is an important point due to the fact that it will be impos-

sible to import other drying oils. Some tung oil is being produced in the south, but not to an extent that will make any appreciable difference.

Most of the experimental work done on soybean oil paint has been accomplished at the University of Illinois Experiment Station. This work was started in 1930, and up to that time practically nothing had been developed in the line of soybean oil paints. Investigations that had been made had very conflicting results, so it was not certain that it could be used satisfactorily for paint even when combined with other oils. In the Illinois experiments, paints were tested in which soybean constituted varying proportions up to fifty per cent of the total liquids used in the paint. A large number of test panel exposures were put out in the spring of 1931. Interior as well as exterior paints were studied. The interior and exterior of buildings on the University of Illinois campus have been painted with soybean paint and the results have been very satisfactory. All of the buildings at the Century of Progress Fair in Chicago were painted with a soybean paint, and it is estimated that one out of every ten farm buildings in Illinois has been painted with this paint.

Mr. A. J. Lewis of the United States Regional Soybean Industrial Products Laboratory at Urbana, Illi-

nois, has written (1) the results of the recent tests. These results were obtained after four years of exposure tests, and may be summarized as follows:

1. Exterior white paints, containing one hundred per cent soybean oil as the oil vehicle and twenty-eight per cent of oil by weight, are equal to enamel linseed oil and blended perilla soybean oil paints in resistance to chalking or surface checking.

2. Similar comparisons of paint with thirty-eight per cent of oil by weight show that the one hundred per cent soybean oil paints are slightly superior to the other two oil paints, (perilla soybean and linseed oil), in resistance to chalking and slightly inferior in surface checking of the paint films.

3. Comparisons of paints with forty-eight per cent of oil by weight show that all the paints containing soybean oil weather away by chalking more rapidly than similar linseed oil paint films.

The experiments made were intended to give soybean oil paint a very severe test. Mr. Lewis says this in conclusion:

> ". . . results show that paints made with 100% soybean oil or with blended soybean perilla

(1) Lewis, A. J., Comparative Durability of Soybean, Soybean Perilla, and Linseed Oil Paints, Oil Paint and Drug Reporter, Vol. 140, August 25, 1941, P. 38.

> "oils when clearly formulated with the proper pigments and driers are equal in durability to similarly formulated linseed oil paints even when the paints there were dried on the very short schedule of only twenty-four hours between coats." (1)

There is a possibility in future development that the wild soybean may be used, as it is a quick dryer. The problem is to combine the oil quality of the wild bean with the oil quantity of some of the standard varieties. There is also a possibility that the paint may be made without oil. This will take the form of a dry powder extracted from the soybean, which, when mixed with water, will give a protective coating more durable than any of the paints now in use. Recent experiments have been made at the Research Laboratory in Urbana on traffic paint. Traffic paint must be durable, quick drying, and must retain its color. An organic chemical which acts as an accelerator has been discovered. The soybean oil is cooked with this chemical and combined with a resin or gum to make a varnish type of coating. Tests are being made on the highways of a midwestern state.

(1) Lewis, A. J., Comparative Durability of Soybean, Soybean Perilla, and Linseed Oil Paints, Oil Paint and Drug Reporter, Vol. 140, August 25, 1941, P. 38.

Edible Oils

Most of the oil that is manufactured goes into edible products of some form. Soybean oil has low free fatty acid, low refining loss, and good flavor and color. It has one drawback which has probably retarded its growth. The oil tends to revert if left standing for awhile, and it acquires a peculiar grassy flavor. The oil must be refined, bleached, winterized, and deodorized to remove part or all of the color and odorous constituents.

In the production of shortening and oleomargarine, soybean oil is hydrogenated after it is refined, and then bleached and deodorized. In the manufacture of oleomargarine it may be blended with some other oil as cottonseed or coconut oil, or oleomargarine may be made wholly from milk and soybean oil. The general process is,

> "Whole milk is inoculated with a mixed culture and incubated or ripened to produce the necessary amount of lactic acid and flavoring constituents required to impart the essential butter flavor to the finished product." (1)

Other minor ingredients are added to the proportioned milk and oil in emulsifying churns where they are emulsified to form a creamy liquid. This crystallizes and

(1) United States Regional Soybean Industrial Products Laboratory, Soybean Oil, April, 1941, P. 4.

forms the finished product known as oleomargarine.

In manufacturing vegetable shortening and lard compounds the hydrogenated oil is blended with other fats and oils, particularly hydrogenated cottonseed oil. Lecithin, a yellow plastic material which darkens rapidly on exposure to air, increases the creaming qualities of shortening. Soybean lecithin is produced commercially, and is used in small quantities as an emulsifying, wetting, or stabilizing agent in a large variety of products including confections, pharmaceuticals, shortening, and textile and leather finishes.

Mr. Lamar Kishlar, Research Director of the Ralston-Purina Company, believes that the soybean oil used in food industries can be improved only as the variety of oil is improved. Quoting Mr. Kishlar,

> "Four out of every five gallons go into food where light colored oil of bland flavor is demanded. Isn't this reason enough why we growers and crushers should give more attention to the yellow variety of beans which give light colored bland oil?" (1)

Soybean oil constituted 17.8 per cent of the ingredients of shortening in 1940, while cottonseed was used to the extent of 68.8 per cent. Margarine

(1) Kishlar, Lamar, The Demand Is for Bland Oil, The Soybean Digest, Vol. 1, September, 1941, P. 17.

soybean oil consumption for the same year was 34 per cent, as compared with cottonseed oil's 45.3 per cent. Soybean oil is being used in increasing quantities in the food industries. Now that other oils will not be imported, it may be expected that all previous records will be broken. Its future consumption after the war will depend on the improved production and manufacturing methods that are developed.

Soap

During the first World War large quantities of soybean oil, imported from Manchuria, were used in the manufacture of soap. With the return of normal conditions its use for this purpose decreased quite rapidly. Unless soybean oil is blended with other fats, it is not particularly suited for high-grade soaps for toilet purposes, or for washing delicate fabrics. Soaps made from soybean oil are used primarily for washing cars and other metal surfaces, and for cleansing marble and tile floors. Calcium soap derived from soybean oil is used in certain types of lubricating greases. The Regional Soybean Industrial Products Laboratory summarizes the use of soybean oil for soap in the following terms:

> "When properly hydrogenated, soybean oil can be substituted for tallow in the production of laundry and certain types of toilet soaps,

"while the soaps derived from the sulfonated oil are used as wetting and emulsifying agents. In the course of conversion of soybean oil into soap or fatty acids, there is simultaneously produced approximately 10 per cent glycerine which is recovered and marketed for various purposes." (1)

A patent has been issued to two German scientists for a shaving soap that will stop bleeding from razor nicks. Three to ten per cent of an abstract obtained from soybean is added to ordinary soap. It is claimed that this extract will not affect the lathering properties of the soap.

(1) United States Regional Soybean Industrial Products Laboratory, <u>Soybean Oil</u>, April, 1940, P. 2.

SOYBEANS FOR FOOD

Ancient proverbs have described the soybeans as the "poor man's meat and the poor man's milk." Long before written records were kept soybeans were used as a main source of food. But the soybeans have been slow in "catching on" in the United States. The United States Department of Agriculture has introduced and experimented with garden varieties for many years. In 1917 the United States Government sent to China Dr. Yamei Kin, a Chinese woman graduate of an American college, to gather facts about the soybean as food. In an interview before she left, Dr. Kin gave the plausible explanation why the soybean has been so important in the diet of the Chinese, that, instead of taking the long and expensive method of feeding grain to an animal until the animal is ready to be killed and eaten, the Chinese way takes a short cut by eating the soybean which is protein, milk, and meat itself. However, the vegetable type soybean did not make much headway until Dr. Morse returned from his China-Japan trip in 1931.

What do soybeans contain that makes them so desirable as a bean and that has provided a balanced diet for the Chinese all of these years? The soybeans are rich in protein and oil. They contain on an aver-

age thirty-five to forty per cent protein, eighteen to twenty per cent oil, one to three per cent lecithin, no starch to speak of, very little sugar, a fair supply of vitamins, and a fair amount of mineral salts. In a pamphlet published by the Edison Institute at Dearborn, Michigan, it is revealed that, compared with other foods, the protein content is:

$1\frac{1}{2}$ times as much as cheese, peas or navy beans,

2 times as much as meat, fish, or lima beans,

3 times as much as eggs or whole wheat flour,

11 times as much as milk.

The oil content as compared with other foods is:

$1\frac{1}{2}$ times as much as cheese, almonds or peanuts,

2 times as much as average meat,

5 times as much as milk or fish,

10 times as much as whole wheat flour.

They are rich in potassium and alkali producing salts. They contain more calcium and phosphorus than any of the cereals, and excel most foods as a source of available iron. They are good sources of Vitamins A, B, and G; contain varying amounts of C, D, E, and K. Experiments have shown that they are a fairly good source of the dietary essential amino acids.

Thus, it would seem that the content of the

soybean would indicate it to be a very good food. Furthermore, the soybean as compared with other foods of the same value, is very cheap.

Green Soybeans

Soybean food products are varied and interesting. At least seventy-five garden varieties have been developed. The Iowa Experiment Station, after working on hundreds of varieties of vegetable soybeans, is now doing its work on three varieties; the Sac, the Kanro, one of the best vegetable beans from the standpoint of palatability and yield, and the Jogun. The Sac has not been released by the Department. Other State Departments recommend additional varieties. The United States Department of Agriculture recommends over forty varieties. As mentioned before in this paper, vegetable soybeans can be grown in practically every state.

As compared with other leading varieties of yellow field beans, according to experiments at the Iowa Station, soybeans are superior in palatability and texture. The advantage of planting soybeans for home consumption as a green vegetable is they are available as a green vegetable at a season of the year when other garden crops on the farm are likely not to be abundant. By planting three or four varieties maturing at differ-

ent times, a continuous supply of green shell beans are available for a period of five or six weeks, and in some seasons and some localities, the period may be even longer.

The one disadvantage of the green vegetable soybean is that it is difficult to shell. The Chinese often boil them right in the shell, and eat them directly from the shell. The Bureau of Economics of the United States Department of Agriculture recommends that to shell the beans, boil them first in the pods three to five minutes. They are then removed from the pods and steamed or boiled in salted water. The time of cooking depends on the variety, some cook as quickly as green peas, others are more like lima beans. The green soybeans are very palatable. The United States Bureau of Home Economics says,

> "The best varieties of green soybeans when done are not mealy. They have a very firm texture and nutty flavor. Because they are so rich they need only simple seasoning with salt and pepper to taste and a little melted butter or crisply fried bacon or salt pork." (1)

There are many suggestions for serving green soybeans. They may appear in the form of scalloped

(1) United States Department of Agriculture, Soybeans for the Table, Leaflet No. 166, October, 1938, P. 2.

dishes, mixed with tomato or white sauce; the cold beans may be used in a green salad. Following the example of the Chinese, they may be cooked and served in the pods, eaten from the fingers after being dipped in melted butter seasoned with soy sauce.

Vegetable Dried Beans

If the beans are allowed to grow until they are dry beans there is great danger of shattering, and consequently a resulting loss. This is one of the main reasons why the beans have not beed developed more in this country. The dry beans may be prepared and served in much the same way as other dry beans, except many varieties require longer cooking. All varieties should be soaked over night. After soaking, some varieties will cook in two hours, or fifteen to thirty minutes in a pressure cooker. The beans may be baked as other forms of beans. The cooked soybeans may be pressed through a sieve and the pulp used in making soup, croquettes, loaf, or souffle. The cold soybean pulp may be used for filling for sandwiches or for filling for a pie.

Soybean Sprouts

Soybean sprouts are always shown on the vege-

table markets of the Far East. Soybeans may be successfully sprouted in the home in a flower pot, sink strainer or any container that has holes in it for drainage and can be covered. The beans swell to at least six times their original bulk as they sprout. The beans are soaked over night, then put in the covered container and left in a warm place. They should be flooded with lukewarm water at least four or five times each day. In four to six days the sprouts are two to three inches long. They are used as an addition to raw salads, omelet, souffle, or meat stew. They may be used with soybean curd.

Soybean Milk

Compared with cow's milk, soybean milk contains one-sixth as much calcium, less fat, and no milk sugar. Its protein, though more efficient than any other vegetable protein, is less in quantity and equal in quality to protein in animal milk. Soybean milk may be used as a beverage or in cooking just as animal milk is used. It is of particular value in the diet of those persons who are allergic to cow's milk. Italian doctors found it satisfactory as a baby's food during the first World War. The Dionne quintuplets have had soy "acidophilus milk" since they were four months old. It is believed now, however, that for babies, it should be

supplemented with other foods. Recent experiments at the Queen's Hospital for Children in London, England, show that milk for babies made from dried milk and soybean flour is a very good substitute milk. The new product is called "Yolac", and is made from equal parts of dried milk and soybean flour, with sugar, orange juice, and cod liver oil added.

There are two general methods of making soybean milk. In one method, the beans are soaked, mashed and put in a bag. The bag is then put in luke warm water and worked with the hands five to ten minutes. The "milk" product is boiled for thirty minutes. In the second method the beans are cracked and ground, soaked and boiled, and the mixture strained. The mash that is left may be used in cooking. It is often added to cookies or macaroons. Soybean curd may be prepared from soybean milk by adding vinegar or other acid, or by allowing the milk to ferment naturally in a warm place. Using acid makes it a firmer curd, while fermentation gives it a texture very much like cream cheese. The fermented cheese may be seasoned and used as other soft cheeses. Oriental people use the curd, called "tofu" with other vegetables in hot dishes. It may be added to omelet and souffles as other forms of cheese. The Chinese also make soup noodles out of the curd.

Soy Sauce

Soy sauce is one of the oldest soy foods known in this country, as it has been imported from the Far East for many years. Each family in the Far East makes its own "shoyu", and it is believed that the longer it is aged the better the product. It is sunned for five years, or even as long as thirty; the jar being patiently uncovered every day and covered every night.

The sauce is a dark-brown liquid prepared from a mixture of cooked and ground soybeans, roasted and pulverized wheat, salt, and water. This is inoculated with rice ferment and left in vats or barrels to ferment. Hawaii, China, and Japan have been the chief manufacturers of this product.

Salted Soys

Soybeans that have been soaked and dried may be fried in deep fat as other nuts and salted. These nuts have been appearing on candy stands throughout the middle west for a number of years. They have a flavor similar to roasted peanuts.

Soybeans as Diabetic Food

It has been believed for quite a number of years

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

that, due to the low starch content, soybeans excel as a diabetic food. More recent investigations at the University of Illinois disclose that they do not have the value that has been assumed. It is important in the case of diabetic food to have a uniform starch content. Soybean plants vary so in their chemical composition that no definite statement can be made as to their reliability as a diabetic food. This is brought out in the statement,

> "Plants of the same variety grown under different conditions often show distinct variations in chemical constituents. Plants of the same species but of different varieties exhibit even greater variations. The seasonal variations were as great as the varietal differences." (1)

Possibilities of Canning

A few commercial concerns have canned successfully large packs of green soybeans. The green beans may also be preserved by quick freezing. The matured beans may be canned as navy beans or red kidney beans.

It is believed that edible soybeans offer many possibilities, and that by introduction of soybeans

(1) MacMasters, Mabel M., Woodruff, Sybil, and Klass, Helen, Studies on Soybean Carbohydrates, Industrial and Engineering Chemistry, Vol. 13, July 15, 1941, P. 472.

that are particularly suitable in the green or dry stage, soybeans as a food will eventually be accepted by the American public.

PRESENT STATUS

It would seem that for the present soybeans are pretty well "set". Soybeans surpassed all cash crops in 1941, except the big four; cotton, wheat, corn, and tobacco. Competing oils are not being imported due to the war. To be sure, many of the export markets have been closed. The United States is exporting to some extent to Canada, the South American countries, and to England. England is consuming large quantities of soybean flour.

In this connection, it may be of interest to note, more or less as a review of what has been discussed, now the present war is affecting the industry. It is not being used by the United States alone in this respect. Life says, "but of rice, fish, and soybeans, Japan has enough to keep going indefinitely." (1) Japan has long been one of the chief importers of soybeans, but since 1939 the Manchurian crop has been slowly declining due to lack of labor and poor governmental control. Soybeans are one of the mainstays of the German Army, as discussed previously in this paper. Germany divided the country into sections as early as 1938 denoting which ones were desirable for growing soybeans.

(1) Life, Japan, Vol. 12, January 5, 1942, P. 45.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

The Frafurter Zunting, a German publication, drew attention to the fact that the army could live on soybean preparations while it was advancing in enemy territory. At the end of the Polish campaign there were boasts that soybean food products proved to be as important as cannon. Germany has also been using soybeans for explosives. Then again, German scientists have developed a Diesel engine for motor trucks which uses eighty-eight per cent soybean oil and only twelve per cent gasoline.

The war is affecting the industry in the United States, but perhaps in somewhat different channels. Some writers go so far as to say that the outcome of the war will depend upon the supply of fats and oils, and that the soybean industry in the United States can provide much more than it has before, putting the United States in a very favorable position. Soybean oil in this country must take the place of oils that cannot be imported. More oil will be needed in the paint, the shortening, and margarine industries. Much larger quantities will go into the soap industry. More soybeans will go into flour to be sent to England and for use in our own country. Adhesive material is needed in defense manufacture of planes and in housing developments. Little has been said about the production of glycerine in this country from soybeans, but there is that possibility. This may

be a by-product of the soap industry. Synthetic rubber made from soybeans is a possibility. Plant capacity will have to be tripled in order to produce the casein that will be needed for defense work. However, present demands are for soybean oil products.

There is no problem of a surplus at the present time. The 1941 crop is going into industrial channels at an increasing rate. In addition to this, 1,500,000 additional bushels will have to be reserved for spring planting to take care of the increased acreage in 1942.

FUTURE OF THE SOYBEAN INDUSTRY

The 1942 industry looks very promising. The Government, in its "Food for Victory" drive, wants the acreage of soybeans boosted fifty per cent above the 1941 record. The initial 1942 goal was set at 7,000,000 acres; in January, 1942, this was increased to nine million acres. In distributing this increase, Indiana and Iowa will be brought into the million acre class, along with Illinois. Michigan will be producing on a commercial scale. If the goals as estimated are carried out, the soybean belt will be shifted slightly southward. The twelve southern states of Alabama, Arkansas, Georgia, Kentucky, Lousiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia will grow more than double the 1941 acreage. The most radical upward shifts in soybean acreage are asked in the lower Mississippi Valley, bringing Mississippi, Arkansas, and Louisiana into commercial production. The eastern states of Delaware, Maryland, New Jersey, New York, Pennsylvania, and West Virginia are asked to reduce their combined acreage.

There have been several recent federal legislations that not only affect the present status of the soybean industry, but will have a tendency to affect the future industry. The American Soybean Association is

objecting to the recent freezing of soybean oil prices one and a half cents under cottonseed oil prices. It is claimed that the average spread for the past three years has been less than one-half that amount. Then again, the Federal Surplus Commodities Corporation, in asking for offers on a vegetable shortening, limited these specifications to cottonseed oil. "Such action of the Federal Surplus Commodities Corporation would seem to endanger the future of the soybean as a profitable cash crop." (1) Loan programs by the Federal Government and platform under prices will have a tendency to stimulate production. At the same time, it is feared that if high prices are maintained on corn, farmers, particularly in the corn belt section, will plant corn instead of soybeans. Many states, particularly states where dairying is a major industry, have passed bills curbing or prohibiting the use of soybean oil food products.

An AAA ruling passed in June, 1941, classified soybeans grown for any purpose as an erosion resisting crop. Previously, soybeans harvested by mechanical means were not so classified. Soybeans do have their drawbacks, however, in soil erosion and soil depleting, and this ruling may be changed at a later date.

(1) Soybean Digest, The, Resolution, American Soybean Association, Vol. 2, December, 1941, P. 12.

The 1942 future looks bright for the soybean industry. It was believed a year ago that production had outgrown consumption and there were too many soybeans produced. The war has changed that picture. It seems to the writer that the major problem that will confront the industry in the near future is the consumption of soybean meal. War demands are for oil. To be sure, increasing quantities of meal will be needed in the flour industry and the protein industry, but industrial uses will still consume only a small percentage of the total output. Industrial uses in recent years have been running around five per cent, while approximately ninety-five per cent goes back into livestock feeding. Mr. Noble, Manager of the Swift Company plant in Champaign, Illinois, believes that by doing a "super" job of selling, greater quantities of soybean meal may be sold, and at a higher price. Basing his estimates on the livestock population of the country, the potential market for protein concentrates is around thirteen million tons annually. The average production of all protein concentrates so far has not exceeded four million tons. The price of soybean oil meal has been selling at a discount under cottonseed meal. Mr. Noble says,

> "For a product which is in every way equal and for some uses superior to cottonseed meal, this is wrong, and in my opinion in-

> "dicates a poor selling job on the part of processors, caused in part by the fact that they are not going to be able to dispose of their meal because of the constantly increasing volume of soybeans grown and the increased competition of expanding and new processing facilities, and by other sales and production problems." (1)

There is no guarantee, however, that this meal surplus will be taken care of. It seems probable that the meal surplus will be one of the major problems confronting the soybean industry when the 1942 crop is harvested.

Another problem that will confront producers is facilities for extracting oil. Present processors can take care of more than they have, but when production is increased fifty per cent, this is throwing a heavy load on the processors. The manufacturers have been hoping that the government would include whole beans with their purchases, as well as flour and oil.

Consumption of soybean oil will undoubtedly be decreased after the present war. Also, other countries have large supplies of oil waiting to be exported. This oil will keep five or six years, and if the war ends before that time, soybean oil in this country will have to compete with the oils that we ordinarily import.

Many people feel that the soybean industry in

(1) Noble, Nelson P., Soy Meal Comes Into Its Own, The Soybean Digest, Vol. 1, September, 1941, P. 6.

this country is still in its infancy. Shortages of basic material may open the door for much more experimental work with the soybeans. It is an industry with many possibilities, and perhaps this country will see many advances made in the next few years. The Government has recognized its importance in the present crisis, and we may expect to hear much more about the industry in the near future.

BIBLIOGRAPHY

Note--The writer did not find many references in books. In the book, Economic Plants, the chapter on soybeans was the only chapter read. All articles listed here have been read by the writer. Those indicated with an asterisk have been of particular value in the writing of this paper. The issues of Soybean Digest were of special value, and, although every article used is not listed in this bibliography, frequent references have been made throughout the paper to articles appearing in these magazines.

Books

Horvath, A. A., The Soybean Industry, Chemical Publishing Co., New York, 2nd Edition, 1939.

Stanford, Economic Plants, D. Appleton Century Co., Inc., New York, 1934.

Magazines, Newspapers, Pamphlets, and Periodicals

*Agricultural Situation, The

Fats and Oils, October, 1940, Vol. 24, P. 18.

This Changing Agricultural World--Fats and Oils, Vol. 24, November, 1940, P. 9.

The Soybean Invasion of the Corn Belt, Vol. 21, May, 1937, P. 14.

*Bechel, A. C., Brother, G. H., and McKinney, L. L., Protein Plastics from Soybean Products, Industrial and Engineering Chemistry, Vol. 30, April, 1938, P. 436.

Beeson, K. E., Soybeans in Indiana, Extension Bulletin No. 231, Purdue University, Lafayette, Indiana, May, 1938.

*Boyer, R. A., Soybean Protein Fibers, Industrial and Engineering Chemistry, Vol. 32, December, 1940, P. 1549.

*Brother, George H., Plastic Materials from Farm Products, United States Regional Soybean Industrial Products Laboratory, Urbana, Ill.

*Brother, George H., McKinney, L. L., Protein Plastics from Soybean Products, Industrial and Engineering Chemistry, Vol. 30, November, 1938, P. 1236.

*Brother, George H., McKinney, and Suttle, W. Carter, Protein Plastics from Soybean Products, Industrial and Engineering Chemistry, Vol. 31, January, 1939, P. 1648.

*Burlison, W. L., Recent Development in the Utilization of Soybean Oil in Paint, University of Illinois, Urbana, Ill., Circular 438, September, 1935.

*Burlison, W. L., The Soybean: A Plant Immigrant Makes Good, University of Illinois, Urbana, Illinois, Circular 461, September, 1936.

*Burlison, W. L., Van Doren, C. A., Hackleman, J. C., Eleven Years of Soybean Investigation, University of Illinois, Bulletin 462, January, 1940.

Burmeister, C. A., Special Outlook, Fats, Oils, and Oilseeds, The Agricultural Situation, Vol. 23, November, 1939, P. 16.

Business Week

*A Point for Soya, November 1, 1931, P. 32.

*Food for Victory Goals Go Up Again, January 24, 1942, P. 46.

New Plastic Mixture, June 22, 1940, P. 32.

Soybean Exports Soar, November 11, 1940, P. 17.

*Soybean Paradox, June 21, 1941, P. 62.

Soybean Price Aid, February 28, 1942, P. 75.

Soybean Sits Pretty, August, 1936, P. 21.

Soybean Synthetic, January 3, 1942, P. 42.

Too Many Soybeans? September 14, 1940, P. 63.

*Cates, J. Sidney, Big Time Performance for Soys, Country Gentleman, Vol. 109, March, 1939, P. 23.

Chemical and Metallurgical Engineering
Activated Sludge Treatment of Soybean Wastes, Vol. 48, June 21, 1941, P. 160.

Fats and Oils, Vol. 49, February, 1942, P. 98.

Consumers' Guide
*A Bean with a Past and a Future, Vol. 7, No. 19, October 1, 1941

*Salute to the World Bean, Vol. 3, April 20, 1936.

*Country Gentleman, Proof of the Prophecies, Vol. 108, April 30, 1938, P. 23.

*Crickman, C. W., Adjustments to Meet War Impacts, The Agricultural Situation, Vol. 25, January, 1941.

Crosman, William, Big Soybean Crop Vital War Need, Boston Sunday Post, March 22, 1942, P. 7.

*Deasy, G. F., Geography of the U. S. Soybean Oil Industry, The Journal of Geography, Vol. 40, January, 1941, P. 401.

Deasy, G. F., The Soya Bean in Manchuria, Economic Geography, Vol. 14, July, 1939, P. 303.

Dempsey, Paul, The Soybean As a Garden Vegetable, Horticulture, Vol. 17, April 15, 1939, P. 194.

Economist, The
Soya Bean Supplies, Vol. 140, April 12, 1941, P. 500.
*Soya Beans--World Trade, Vol. 138, January 6, 1941, P. 33.

*Edison Institute, The, Recipes for Soy Bean Foods, Dearborn, Michigan.

Esselen, Gustavus, J., Bacon, Frederick S., Raw Materials of the Plastic Industry, Industrial and Engineering Chemistry, Vol. 30, February, 1938, P. 125.

*Fats and Oils Situation, United States Department of Agriculture, Soybean Loan Program Announced, No. 57, November, 1941, P. 5.

*Food Industries, Soybean Products, November, 1940, Vol. 12, P. 87.

Foreign Commerce Weekly, Vol. III, No. 9, May 31, 1941, P. 394

Foreign Crops and Markets, Soybean Oil Exports, March 24, 1941, P. 263.

Goss, W. H., Modern Plastics in Solvent Extraction, Chemical and Metallurgical Engineering, Vol. 48, April, 1941, P. 80.

*Grove, Ernest W., Soybeans in the United States, Recent Trends and Present Economic Status, United States Department of Agriculture, Technical Bulletin, No. 619, June, 1938.

*Haskin, Frederic J., Scientists Find Soybean Amazing, Boston Traveler, October 17, 1941, P. 61.

Hoard's Dairyman, Soybeans for Silage, Vol. 86, December 10, 1941, P. 720.

*Horvath, A. A., The Soybean Points the Way, The Scientific Monthly, Vol. 45, July, 1936, P. 63.

*Howard, R. W., Little Beans, Big Business, Farm Journal, Vol. 65, P. 18.

*Lewis, A. J., Comparative Durability of Soybean, Soybean Perilla and Linseed Oil Paints, Oil Paint and Drug Reporter, Vol. 140, August 25, 1941, P. 38.

Literary Digest

*From Salad Oil to Paints, Vol. 120, July 27, 1935, P. 17.

Invading Bean, Vol. 121, August 8, 1936, P. 14.

*To Study the Soy Bean for Uncle Sam, Vol. 55, July 14, 1917, P. 52.

*Lloyd, J. W., Range of Adaptation of Certain Varieties of Vegetable-Type Soybeans, University of Illinois, Urbana, Ill., Bulletin 471, December, 1940.

*MacMasters, Mabel M., Woodruff, Sybil, and Klass, Helen, Studies on Soybean Carbohydrates, Industrial and Engineering Chemistry, Vol. 13, July 15, 1941, P. 472.

Mann, Dr. H. H., Soya Bean Culture in Great Britain, Nature, Vol. 147, May 31, 1941, P. 127.

McBride, Gordon W., What's Happening with Soybeans? Food Industries, October, 1940, Vol. 12, P. 55.

Mechanical Engineering, Plastics in Transportation at Ford Plant, Vol. 62, March, 1940, P. 235.

Morgan, Helen, Jack in the Beanstalk, Scribner's Commentator, April, 1941, Vol. 9, P. 82.

*Morse, W. J., The Soybean Industry, United States Department of Agriculture, Yearbook, 1917, P. 102.

*Morse, W. J., Soybean Utilization, United States Department of Agriculture, Farmers' Bulletin, No. 1617, January, 1930.

*Morse, W. J., Cartter, J. L., Soybeans--Culture and Varieties, United States Department of Agriculture, Bulletin No. 1520, November, 1939.

*Morse, W. J., Piper, C. V., The Soy Bean; History, Varieties, and Field Studies, United States Department of Agriculture, Bulletin No. 197, December 31, 1910, P. 3.

New York Times

Britain Buys Manchukuon Product, February 26, 1940, P. 23.

C. E. A. Urges Greater Government Control, November 27, 1941, P. 35.

Chicago Board of Trade Complies with Wickard's Request, November 9, 1941, P. III-5.

New York Times

*Deliveries from Bessarabia to Germany, July 5, 1940, P. 7.

*Department Chemists Begin Work on the Problem of Extractin_ Protein, July 27, 1941, P. II-5.

*Ford Ready to Make a Fiber of Soybeans. December 25, 1941, P. 6.

Germans in China Exploit Diesel Engine Using Soybean Oil, March 5, 1940, P. 31.

Growing U. S. Importance, May 26, 1940, P. 12-M.

How Soybeans May Be Used to Extinguish Fires, January 18, 1942, P. II-8.

*Japan Held Ruining North China Farms, June 21, 1941, P. 4.

Mrs. B. F. Johnston Urges Increased U. S. Crop, November 11, 1941, P. 22.

*Limitations on Soybeans, December 10, 1941, P. 44.

*Manchurian Soybean Export Cut, August 3, 1940, P. 18.

New Fiber to Be Made From Soya Bean in China, September 12, 1940, P. 12.

New Soybean Contract Set Up, June 7, 1941, P. 24.

New York Produce Exchange Orders 15% Margin on Oil Contracts, July 19, 1941, P. 19.

New York Trading Begun in Soybean Oil, September 4, 1940, P. 35.

*Parity Prices on Soybeans, August 4, 1940, P. 24.

*Plastic Helmet, December 7, 1941, P. II-7.

Record Soybean Crop, April 19. 1940, P. 38.

Restores Trading in Oils, January 3, 1942, P. 23.

*Shaving Soap, January 7, 1940, P. II-7.

Shipments of Soybeans Sent Back to Chicago, April 26, 1940, P. 40.

Soybeans Break Under Pressure, October 4, 1941, P. 23.

Soybean Exports Cut, January 11, 1941, P. 27.

Soybean Exports Up, November 5, 1940, P. 41.

Soybeans, Grains Have Big Day, September 9, 1941, P. 37.

Soybeans Made More Palatable, January 4, 1942, P. II-7.

Soybeans Once a Curiosity, January 1, 1942, P. 32.

Soybeans Strong on U. S. Price Decision, June 16, 1941, P. 26.

*Soybean Train of Baltimore and Ohio Will Tour Three States, February 22, 1941, P. 21.

To Freeze Prices of Commodities, December 9, 1941, P. 53.

Trading Is Suspended, December 16, 1941, P. 49.

*Use Soybeans for Lack of Casein, July 24, 1941, P. 12.

*War and Soya Beans, July 7, 1940, P. II-5.

*Wool and Silk from Soya Beans, March 10, 1940, P. II-8.

Newsweek

*Soybean Egg Whites, Vol. 15, January 22, 1940, P. 30.

*Soy Beans--Raiding a Treasure Store of the Vegetable Kingdom, Vol. 7, April 25, 1926, P. 38.

Oil, Paint and Drug Reporter
*Soybean Oil Process, Vol. 139, May 26, 1941, P. 54.

*Soybean Output Helped by New Process, Vol. 140, July 28, 1941, P. 5.

*Popular Mechanics, The Bean That Made Good, Vol. 67, May, 1937, P. 660.

*Primmer, George H., United States Soybean Industry, Economic Geography, Vol. 15, April, 1940, P. 205.

Prince, Ford S., Higgins, L. J., Blood, Paul T., and Percival, G. P., Soybeans in New Hampshire, New Hampshire Agricultural Experiment Station, Circular 57, January, 1941.

*Railway Age, Soybean Show Train to Tour East, Vol. 103, August 2, 1937, P. 246.

*Rayon Textile Monthly, Textile Fiber from Soybean Successful, Vol. 20, June, 1939, P. 319.

*Reed, J. J., Edible Soybeans, Purdue University, Lafayette, Indiana, 1938.

*Review of Reviews, Soybeans for Everything, September, 1936, P. 41.

Robbins and Ramaley, Plants Useful to Man, P. Blakistons Son & Co., Inc., New York, 1933, P. 289.

Rural New York, Experience with Raising Soybeans, Vol. 103, June 4, 1938, P. 383.

*Rusk, H. P., Nevens, W. B., Kammlade, W. G., Edmonds, J. L., Crawford, C. W., Carroll, W. E., and Sloan, H. J., Utilizing the Soybean Crop in Livestock Feeding, University of Illinois, Urbana, Ill., Circular 369, June, 1937, 2nd Edition.

*Russell, Joseph A., Synthetic Products and the Use of Soy Beans, Economic Geography, Vol. 18, January, 1942, P. 29.

Sales Management, $20,000,000 a Year in By-Products, How Ford Retrieves and Markets Them, Vol. 49, August 1, 1941, P. 18.

Scholastic, Soybeans May Solve Farm Problems, Vol. 39, November 7, 1936, P. 12.

Science

*The Soybean Crop in the United States, Vol. 93, January 24, 1941, P. 86.

*Soybean Rubber, Vol. 95, January 9, 1942, Supplement, P. 10.

*Synthetic Fiber from Soya Beans, Vol. 91, March 15, 1940, Supplement, P. 13.

Yarn from Soybeans, Vol. 87, May 28, 1938, Supplement, P. 10.

Science Digest, Bee Bread from Soybeans, Vol. 9, May, 1941, P. 88.

Science News Letter

*Fiber and Cloth Made from Soybean Protein, Vol. 34, August 13, 1938, P. 105.

Germany Undertakes Raising of Own Soybean Supplies, Vol. 33, March 26, 1938, P. 200.

*Nation's Soybean Lab Develops 36 Varnishes, Vol. 34, July 16, 1938, P. 39.

*New Fiber Made from Soybean Protein to Be Used in Autos, Vol. 33, May 7, 1938, P. 320.

*Plastic Made of Soybean Offers Use for Farm Products, Vol. 33, January 29, 1938, P. 71.

*Soybean Fiber, Vol. 39, March 10, 1941, P. 148.

*Soybeans for Human Food, Vol. 37, April 13, 1940, P. 229.

*Soybean Proteins to Replace Milk Casein, Vol. 40, August 9, 1941, P. 89.

Scientific Monthly

Catching Up with China, Vol. 17, September, 1923, P. 283.

Scientific Monthly
German Soybean Supplies, Vol. 47, April, 1938, P. 377.

*Soy, Vol. 18, January, 1924, P. 109.

*Soybean Varnishes, Vol. 47, August, 1938, P. 169.

*Sears, O. H., Soybeans: Their Effect on Soil Productivity, University of Illinois Agricultural Experiment Station, Urbana, Illinois, Bulletin 456, June, 1939.

Skinner, J. H., Feeding Soybeans and Soybean Oilmeal on Indiana Farms, Purdue University, Extension Bulletin No. 180, Second Revised Edition, May, 1938.

Smith, Allan K., Circle, Sidney, J., Pepitization of Soybean Proteins, Industrial and Engineering Chemistry, Vol. 30, December, 1938, P. 1414.

*Soybean Digest, The, Official Publication of the American Soybean Association, Hudson, Iowa.
Volume 1, No. 1, November, 1940
Volume 1, No. 2, December, 1940
Volume 1, No. 3, January, 1941
Volume 1, No. 5, March, 1941
Volume 1, No. 6, April, 1941
Volume 1, No. 7, May, 1941
Volume 1, No. 9, July, 1941
Volume 1, No. 10, August, 1941
Volume 1, No. 11, September, 1941
Volume 1, No. 12, October, 1941
Volume 2, No. 2, December, 1941
Volume 2, No. 4, February, 1942
Volume 2, No. 5, March, 1942

Sweinhart, James, Ford and the Coming Agrindustrial Age, Form No. 7460, April, 1940

Textile Colorist, Rayon from Soya Beans, Vol. 63, August, 1941, P. 457.

Time
Babassu, Have You Any Soap?, Vol. 39, January, 19, 1942, P. 74.

Time
*Jack and the Soybean, Vol. 38, September 15, 1941, P. 38.

*Little Honorable Plant, Vol. 28, October 12, 1936, P. 76.

*Plastic Fords, Vol. 26, November 11, 1940, P. 65.

United States Department of Agriculture, Agricultural Statistics, 1941, P. 299-304.

United States Department of Agriculture, Crops and Markets, Vol. 17, December, 1940.

United States Department of Agriculture, Farm Production, Farm Disposition and Value of Soybeans and Cowpeas, June, 1940.

United States Department of Agriculture, Farmers in a Changing World, Soybeans, 1940.

United States Department of Commerce, Industrial Reference Series, Part 3, Foodstuffs, Soybean Oil,
No. 74, September, 1941
No. 78, September, 1941
No. 82, October, 1941
No. 91, November, 1941

United States Department of Agriculture, Yearbook, Soybeans, Years, 1903, 1904, 1907, 1908, 1917, 1918, 1923, 1924.

*United States Regional Soybean Industrial Products Laboratory, Soybean Oil, April, 1940.

Walsh, R. M., Soybeans' New Problem, The Agricultural Situation, March, 1940, P. 12.

*Wharton, D., Soybean Pioneer, Readers' Digest, Vol. 38, September, 1940, P. 70.

*Whiteman, Elizabeth Fuller, Keyt, Ellen Kingsley, Soybeans for the Table, United States Department of Agriculture, Leaflet No. 166, 1938.

Williams, Simon, Tonn, W. H., Qualitative Methods of Identifying Soybean Fibers in Mixtures of Casein Fiber, Rayon, Vol. 22, P. 523.

*Wing, Andrew S., Celestial Bean, Nature Magazine, Vol. 34, June, 1941, P. 335.

Worden, Edward C., Filaments from Soya Bean, Rayon, Vol. 22, October, 1941, P. 63.